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| <b>(54) Title:</b> AZABRICYCLIC COMPOUNDS AS CALCIUM CHANNEL ANTAGONISTS<br><br><div style="text-align: center;"> <p style="text-align: center;">(I)</p> </div><br><b>(57) Abstract</b><br><p>Use of compounds of formula (I), in which p, q and r each independently represent an integer from 1 to 4; A is a bond, -CH=CH-, -C≡C-, oxygen, sulphur or NR<sup>1</sup>, where R<sup>1</sup> is hydrogen, C<sub>1-8</sub>alkyl or phenylC<sub>1-4</sub>alkyl; n is 0 to 6, and m is 0 to 6, such that the length of the chain -(CH<sub>2</sub>)<sub>n</sub>A(CH<sub>2</sub>)<sub>m</sub> is at least two atoms; and Ar is aryl or heteroaryl, each of which may be optionally substituted; and pharmaceutically acceptable salts thereof, for the manufacture of a medicament for the treatment of disorders where a calcium channel antagonist is indicated. Novel compounds of formula (I), processes for preparing them and pharmaceutical compositions containing them are also described.</p> |           |   |

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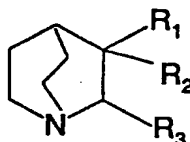
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## AZABRICYCLIC COMPOUNDS AS CALCIUM CHANNEL ANTAGONISTS

The present invention relates to the use of known and novel azabicyclic derivatives in  
 5 therapy, in particular as calcium channel antagonists, novel compounds *per se*, processes  
 for their preparation, and pharmaceutical compositions containing them.

US Patent No. 4,599,344 describes quinuclidines of the formula :



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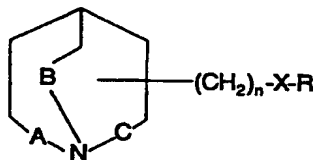
wherein  $R_1$  is *inter alia* hydrogen,  $R_2$  is hydrogen or  $ALK-Z$  and  $R_3$  is hydrogen or  
 $ALK''-Z$ , where  $ALK$  is  $C_{2-4}$ alkyl,  $ALK''$  is  $C_{1-4}$ alkyl and  $Z$  is a mono- or di-substituted  
 15 phenyl ring. These compounds are said to be antiarrhythmic agents.

15

Ricciardi and Doukas (Heterocycles, Vol 24, No 4, p971, 1986) describe certain  
 styrylquinuclidines, which are said to inhibit cholineacetyl-transferase *in vitro*.

German OLS 41 16582 describes azabicyclic compounds of the formula :

20



wherein A, B and C independently represent  $-CH_2-$  or a single bond; n is zero, 1 or 2; X is  
 25 oxygen or sulphur and R is *inter alia* phenylalkyl, diphenylalkyl, heterocyclicalkyl, phenyl,  
 diphenyl or a heterocycle, each of which may be optionally substituted. These compounds  
 are said to be useful as muscarinic antagonists.

25

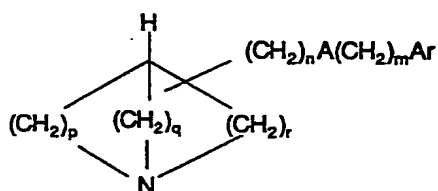
EPA 497415 describes 3-(substituted phenoxy and substituted phenylthio)quinuclidines,  
 wherein the phenyl substituent is selected from *inter alia* lower alkoxy, lower aralkyloxy,  
 30 halogen,  $NO_2$ ,  $CF_3$ , CN and  $NR_1R_2$ , which compounds are said to be muscarinic agonists.

30

We have now found that certain substituted azabicyclic derivatives, including some of the above compounds, exhibit activity as calcium channel antagonists. They are thus of potential use in the treatment of disorders where calcium channel blockade is indicated, in particular disorders related to an accumulation of calcium in the brain cells of mammals.

5

The present invention therefore provides, in a first aspect, the use of a compound of formula (I):



10

Formula (I)

in which

15 p, q and r each independently represent an integer from 1 to 4;

A is a bond,  $-\text{CH}=\text{CH}-$ ,  $-\text{C}\equiv\text{C}-$ , oxygen, sulphur or  $\text{NR}^1$ , where  $\text{R}^1$  is hydrogen,  $\text{C}_{1-8}$ alkyl or phenyl $\text{C}_{1-4}$ alkyl;

20 n is 0 to 6, and m is 0 to 6, such that the length of the chain  $-(\text{CH}_2)_n\text{A}(\text{CH}_2)_m$  is at least two atoms; and

Ar is aryl or heteroaryl, each of which may be optionally substituted;

25 or a pharmaceutically acceptable salt thereof, for the manufacture of a medicament for the treatment of disorders where a calcium channel antagonist is indicated.

The H atom is shown on the bridgehead carbon atom to make clear that the  $(\text{CH}_2)_n\text{A}(\text{CH}_2)_m\text{Ar}$  chain cannot be attached at this position.

30 The compounds of formula (I) have been found to exhibit high calcium influx blocking activity for example in neurons. As such the compounds are expected to be of use in therapy, particularly in treating conditions and diseases related to (e.g. caused or exacerbated by) an accumulation of calcium in the brain cells of mammals, in particular humans. For example, the compounds are expected to be of use in the treatment of

anoxia, ischaemia including for example stroke, migraine, epilepsy, traumatic head injury, AIDS-related dementia, neurodegenerative diseases such as Alzheimer's disease and age-related memory disorders, and drug addiction withdrawal such as ethanol addiction withdrawal.

5

In a further aspect of the invention there is also provided a method of treatment of conditions or diseases related to (e.g. caused or exacerbated by) the accumulation of calcium in the brain cells of mammals which comprises administering to a subject in need thereof an effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof. Thus, for example, the present invention provides a method of treatment of  
10 anoxia, ischaemia including for example stroke, migraine, epilepsy, traumatic head injury, AIDS-related dementia, neurodegenerative diseases such as Alzheimer's disease and age-related memory disorders, and drug addiction withdrawal such as ethanol addiction withdrawal, which comprises administering to a subject in need thereof, an effective  
15 amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof.

In the compounds of formula (I) p and r are preferably independently 2 or 3; most preferably both are 2.

20 q is preferably 1 or 2.

The values of m and n should be chosen such that the length of the chain  $(\text{CH}_2)_n\text{A}(\text{CH}_2)_m$  is at least 2 atoms. In general the length of the chain  $-(\text{CH}_2)_n\text{A}(\text{CH}_2)_m$  is from 2 to 6 e.g. 2 to 5 atoms. Preferred values for n and m depend on the group A. Thus for example  
25 when A is oxygen the sum of n+m is preferably from 1 to 5, for example n may be 1, 2, 3 or 4 and m may be 0 or 1.

When A is a bond the sum of n+m should be at least 2, e.g. n+m may be 2 or 3. When A is  $\text{CH}=\text{CH}$  one or both of n and m may be zero, e.g. n may be zero or 1 and m may be  
30 zero.

A is preferably oxygen, a bond or  $-\text{CH}=\text{CH}-$ ; most preferably A is oxygen.

When Ar represents aryl, suitable groups include, for example, unsaturated monocyclic and unsaturated or partially saturated bicyclic or tricyclic ring systems of up to 15 carbon  
35 atoms, such as, for example, phenyl, naphthyl, tetrahydronaphthyl, fluorene, fluorenone, dibenzosuberene and dibenzosuberone. Preferred are optionally substituted phenyl rings.

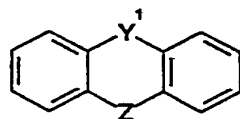
An aryl group may be substituted, for example, by a C<sub>1-2</sub>alkylenedioxy group (e.g. phenyl substituted by a 3,4-methylenedioxy group) or by 1 to 3 substituents selected from halogen, C<sub>1-4</sub>alkoxy, nitro, SC<sub>1-4</sub>alkyl, NR<sup>2a</sup>R<sup>2b</sup> (in which R<sup>2a</sup> R<sup>2b</sup> can be  
 5 independently H or C<sub>1-4</sub>alkyl), OCF<sub>3</sub>, C<sub>1-6</sub>alkyl, trifluoromethyl, CN, optionally substituted phenyl, optionally substituted phenoxy, optionally substituted phenylC<sub>1-4</sub>alkyl and optionally substituted phenylC<sub>1-4</sub>alkoxy.

Suitable optionally substituted phenylC<sub>1-4</sub>alkyl groups include, for example benzyl.  
 10 Suitable optionally substituted phenylC<sub>1-4</sub>alkoxy groups include, for example benzyloxy groups.

Suitable substituents for said optionally substituted phenyl, phenoxy, phenylC<sub>1-4</sub>alkyl and phenylC<sub>1-4</sub>alkoxy groups include for example  
 15 halogen, C<sub>1-4</sub>alkyl, C<sub>1-4</sub>alkoxy, nitro and trifluoromethyl groups.

Preferably the aryl group is a phenyl ring substituted by one or two substituents, in particular, by a phenyl; phenyl(C<sub>1-4</sub>)alkyl, e.g. benzyl or phenethyl; phenoxy; or phenylC<sub>1-4</sub>alkoxy group; which groups may themselves be optionally substituted by halo,  
 20 e.g. chloro.

When Ar represents heteroaryl suitable groups include, for example, unsaturated or partially saturated bicyclic and tricyclic ring systems containing at least one heteroatom. A bicyclic ring system preferably contains 8 to 10 ring members, such as quinolinyl, tetrahydroquinolinyl or benzofuranyl. A tricyclic ring system preferably contains from 11  
 25 to 15 ring members, and most preferably has the structure :



30 wherein Y<sup>1</sup> represents Y(CH<sub>2</sub>)<sub>t</sub>, Y is O, S or NR<sup>3</sup> (where R<sup>3</sup> is hydrogen or C<sub>1-4</sub>alkyl), Z is (CH<sub>2</sub>)<sub>s</sub> or -CH=CH-, s is 0, 1 or 2 and t is 0 or 1 or is a corresponding dehydro ring system. Examples of tricyclic heteroaryl groups include dibenzofuranyl, dibenzothienyl, carbazole, N-methylcarbazole, acridine and dibenzoxepine. The heteroaryl ring can be linked to the remainder of formula (I) via any suitable ring atom.

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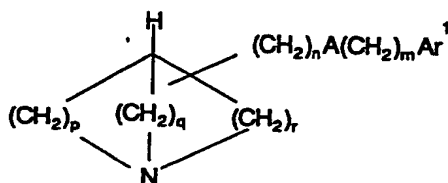
Suitable substituents for said heteroaryl rings

include, for example, 1 to 3 substituents selected from halogen, trifluoromethyl, C<sub>1-4</sub>alkyl, C<sub>1-4</sub>alkoxy, phenyl, phenylC<sub>1-4</sub>alkyl and phenylC<sub>1-4</sub>alkoxy.

Alkyl groups present in the compounds of formula (I), alone or as part of another group, can be straight or branched. Thus a C<sub>1-4</sub>alkyl group may be for example methyl, ethyl, n-propyl, n-butyl or any branched isomer thereof such as isopropyl or t-butyl.

It will be appreciated that for use in medicine a salt of a compound (I) should be pharmaceutically acceptable. Examples of pharmaceutically acceptable salts include inorganic and organic acid addition salts such as hydrochloride, hydrobromide, sulphate, phosphate, acetate, fumarate, maleate, citrate, lactate, tartrate, oxalate, methanesulphonate or similar pharmaceutically acceptable inorganic or organic acid addition salts. Other non-pharmaceutically acceptable salts may be used for example in the isolation of a final product and are included within the scope of this invention.

The invention also provides novel compounds of formula (IA) :



Formula (IA)

in which

p, q and r each independently represent an integer from 1 to 4;

n is 0 to 6;

m is 0 to 6, and

either

A is -C≡C- or NR<sup>1</sup>, where R<sup>1</sup> is hydrogen, C<sub>1-8</sub>alkyl or phenylC<sub>1-4</sub>alkyl;  
in which case Ar<sup>1</sup> represents the group Ar as hereinbefore defined;

or A is a bond, in which case Ar<sup>1</sup> represents the group Ar as hereinbefore defined with the proviso that when each of p, q and r is 2 and Ar is phenyl substituted by one or two groups selected from halogen, C<sub>1-4</sub>alkoxy, nitro, cyano or amino, then the group -(CH<sub>2</sub>)<sub>n</sub>A(CH<sub>2</sub>)<sub>m</sub> is not C<sub>1-4</sub>alkyl α to the quinuclidine nitrogen atom or C<sub>2-4</sub>alkyl β to the quinuclidine nitrogen atom,

5 or A is  $-\text{CH}=\text{CH}-$  in which case  $\text{Ar}^1$  represents the group Ar as hereinbefore defined with the proviso that when each of p, q and r is 2; n and m are both zero and Ar is mono- or di-chlorophenyl, the group  $-(\text{CH}_2)_n\text{A}(\text{CH}_2)_m$  is not  $\beta$  to the quinuclidine nitrogen atom.

10 or A is oxygen or sulphur in which case  $\text{Ar}^1$  represents a group  $\text{Ar}^2$  which is phenyl substituted by a  $\text{C}_{1-2}$ alkylenedioxy group or by 1 to 3 substituents selected from  $\text{SC}_{1-4}$ alkyl,  $\text{OCF}_3$ ,  $\text{CF}_3$ , optionally substituted phenoxy, optionally substituted phenyl $\text{C}_{1-4}$ alkyl and optionally substituted phenyl $\text{C}_{1-4}$ alkoxy; or  $\text{Ar}^2$  is

an optionally substituted bicyclic or tricyclic aryl group of up to 15 carbon atoms;

15 an optionally substituted benzofuranyl group; or an optionally substituted tricyclic heteroaryl group;

and salts thereof.

20 Suitable substituents for said optionally substituted phenoxy, phenyl $\text{C}_{1-4}$ alkyl and phenyl $\text{C}_{1-4}$ alkoxy groups are as hereinbefore defined.

Bicyclic and tricyclic aryl and heteroaryl groups for  $\text{Ar}^1$  and  $\text{Ar}^2$  include those defined hereinbefore for the group Ar.

25 In the compounds of formula (IA), p and r are preferably 2 or 3; q is preferably 1 or 2.

A is preferably O,  $-\text{CH}=\text{CH}-$  or a bond,

n is preferably zero, 1 or 2;

m is preferably zero or 1;

30  $\text{Ar}^1$  is preferably  $\text{Ar}^2$  as defined above, or when A is  $-\text{CH}=\text{CH}-$  or a bond Ar may also represent phenyl substituted by an optionally substituted phenyl group.

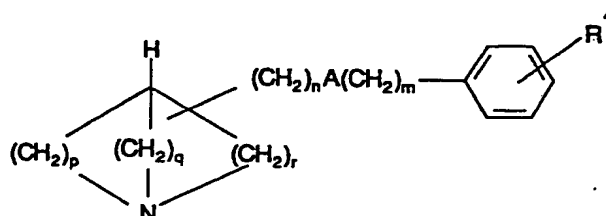
A bicyclic aryl group is preferably naphthyl.

35 A bicyclic heteroaryl group is preferably benzofuranyl.

A tricyclic heteroaryl group is preferably dibenzofuranyl.



A particular group of compounds according to the invention is that represented by formula (IB)



5

Formula (IB)

wherein p, q, r, n, m and A are as defined for formula (IA) and R<sup>4</sup> represents optionally substituted phenoxy, optionally substituted phenylC<sub>1-4</sub>alkyl or optionally substituted phenylC<sub>1-4</sub>alkoxy, or R<sup>4</sup> represents a fused benzene ring; and salts thereof.


10

Preferred meanings for p, q, r, n, m, and A are as described for formula (IA).

Most preferably A represents oxygen.

15

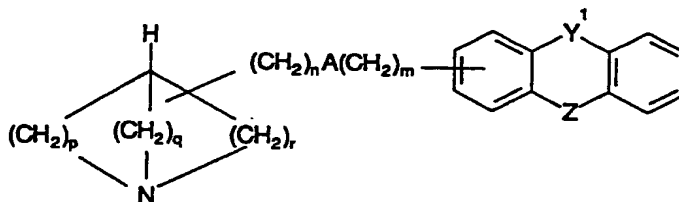
It will be appreciated that when R<sup>4</sup> represents a fused benzene

ring the group  is a naphthyl group.

R<sup>4</sup> preferably represents benzyl, benzyloxy or phenoxy, or is a fused benzene ring.

Another group of compounds according to the invention is that of formula (IC) :

20



Formula (IC)

25

wherein p, q, r, n, m and A are as defined for formula (IA) and Y<sup>1</sup> and Z are as hereinbefore defined for formula (I); and salts thereof.

Most preferably Y<sup>1</sup> is oxygen and Z is a bond.

Particular compounds of the invention include:

- 5 (±)3-(3,4-dichlorophenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(4-benzyloxyphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(4-benzylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(2-phenylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(4-tert-butylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- 10 (±)3-(1-naphthylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(2-dibenzofuranyloxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(5-isoquinolinyloxy)ethyl-1-azabicyclo[2.2.2]octane hydrochloride,
- (±) endo-3-(4-benzylphenoxyethyl)-1-azabicyclo[2.2.1]heptane hydrochloride,
- (±) endo-3-(4-benzyloxyphenoxyethyl)-1-azabicyclo[2.2.1]heptane hydrochloride,
- 15 (±) exo-3-(4-benzylphenoxyethyl)-1-azabicyclo[2.2.1]heptane hydrochloride,
- (±) exo-3-(4-benzyloxyphenoxyethyl)-1-azabicyclo[2.2.1]heptane hydrochloride,
- (±) E-3-[2-(1-naphthyl)ethenyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)E-3-[2-(4-biphenyl)ethenyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-[2-(1-naphthyl)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- 20 (±)3-[2-(4-biphenyl)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)E-3-[3-(1-naphthyl)prop-2-enyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-[3-(1-naphthyl)propyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-[2-(2-dibenzofuranyloxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-[2-(4-benzyloxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- 25 (±)3-[2-(4-benzylphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±)3-(4-phenoxyphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride,
- (±) 3-[2-(4-phenoxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±) 3-[4-(2-dibenzofuranyloxy)butyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±) 3-[4-(4-phenoxyphenoxy)butyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- 30 (±) 3-[3-(4-phenoxyphenoxy)propyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±) 3-[2-[4-(2-phenylethyl)phenoxy]ethyl]-1-azabicyclo [2.2.2]octane hydrochloride,
- (±) 3-[2-[4-[2-(4-chlorophenyl)ethyl]phenoxy]ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- (±) 3-[2-[5-(2-phenyl)benzo[b]furanyloxy]ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,
- 35 (±) 2-[2-(4-benzylphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride,

(±) 2-[2-(4-benzyloxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride

(±) 2-[2-(4-phenoxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride, and

(±) 4-[2-(4-phenoxyphenoxy)ethyl]-1-azabicyclo[3.3.1]nonane hydrochloride.

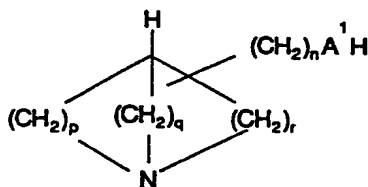
- 5 It will be appreciated that the compounds of formula (I) may contain one or more asymmetric centres. Such compounds will exist as optical isomers (enantiomers). Both the pure enantiomers, racemic mixtures (50% of each enantiomer) and unequal mixtures of the two are included within the scope of the invention. Further, all diastereomeric forms possible (pure enantiomers and mixtures thereof) are within the scope of the invention. In  
10 addition, when A represents  $-\text{CH}=\text{CH}-$  the compounds will exist as geometric isomers, and the invention encompasses all such isomers and mixtures thereof.

In compounds of formula (I) having two asymmetric centres the stereochemical configuration in which the group  $-(\text{CH}_2)_n\text{A}(\text{CH}_2)_m\text{Ar}$  and the  $(\text{CH}_2)_q$  bridge are on the  
15 same side of the plane of the molecule which contains both bridgehead atoms and the ring carbon bonded to the group  $-(\text{CH}_2)_n\text{A}(\text{CH}_2)_m\text{Ar}$  will herein be referred to as the *exo* configuration. Similarly the configuration of compounds in which the group  $-(\text{CH}_2)_n\text{A}(\text{CH}_2)_m\text{Ar}$  and the bridge  $(\text{CH}_2)_q$  are on opposite sides of the above-mentioned plane will herein be referred to as the *endo* configuration. Both configurations are within  
20 the scope of this invention.

The compounds of the present invention can be prepared by processes analogous to those known in the art. The present invention therefore provides in a further aspect, a process for the preparation of a compound of formula (I) which comprises:

25

(a) for compounds of formula (I) in which A is O, S or  $\text{NR}^1$ , reaction of a compound of formula (II):

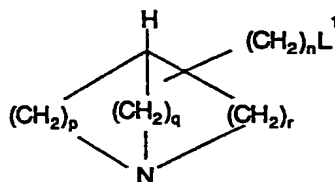


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Formula (II)

in which p, q, r and n are as described for formula (I) and  $A^1$  is O, S or  $NR^1$ , with a compound of formula  $L(CH_2)_mAr$  in which m and Ar are as described for formula (I), and L is a leaving group;

- 5 (b) for compounds of formula (I) in which A is O, S or  $NR^1$ , reaction of a compound of formula (III):



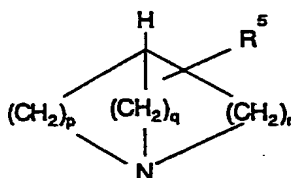
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Formula (III)

in which p, q, r and n are as described for formula (I) and  $L^1$  is a group displaceable by a nucleophile, with a compound of formula  $HA^1(CH_2)_mAr$  where m and Ar are as described for formula (I) and  $A^1$  is as described for formula (II); or

15

- (c) for compounds of formula (I) in which A is  $NR^1$ , reduction of a compound of formula (IV):



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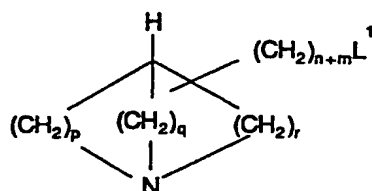
Formula (IV)

in which  $R^5$  represents the group

- 25  $-(CH_2)_nN(R^1)C(O)(CH_2)_{m-1}Ar$  or  $-(CH_2)_{n-1}C(O)N(R^1)(CH_2)_mAr$ ,

and p, q, r, n, m, and Ar are as described for formula (I);

- (d) for compounds of formula (I) in which A is a bond, reaction of a compound of  
30 formula (V):

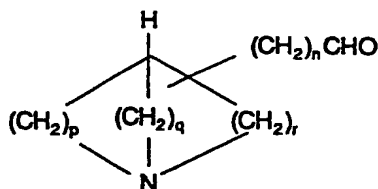


Formula (V)

5 (wherein  $L^1$ ,  $p$ ,  $q$ ,  $r$ ,  $m$  and  $n$  are as hereinbefore defined).

with a compound of formula  $X^1Ar$  in which  $Ar$  is as described for formula (I), and  $X^1$  is an alkali metal;

10 (e) For compounds wherein  $A$  is  $-CH=CH-$  reaction of a compound of formula (VI) :



Formula (VI)

15

(wherein  $n$ ,  $p$ ,  $q$  and  $r$  are as hereinbefore defined) with a reagent serving to introduce the group  $Ar$ ;

(f) Interconversion of one compound of formula (I) to a different compound of  
 20 formula (I) e.g. the reduction of a compound wherein  $A$  is  $-CH=CH-$  to a compound wherein  $A$  is  $-CH_2CH_2-$ ;

and optionally thereafter forming a salt.

25 In process (a) the reaction between a compound of formula (II) and a compound  $L(CH_2)_mAr$  can take place under conditions which depend on the nature of the group  $L$  and the value of  $m$ . For example, when  $L$  is halogen or a sulphonic acid residue such as a tosylate or mesylate and  $m$  is other than zero, the reaction is carried out under standard conditions in a solvent, optionally in the presence of a base. When a fluoro-substituted  
 30 aryl compound  $F-Ar$  is employed in process (a) (to prepare compounds where  $m$  is zero), the reaction is effected in the presence of a strong base such as sodium hydride, and in an

inert organic solvent such as dimethylformamide. Preferably the aryl group is substituted by an activating group such as  $\text{CF}_3$  or  $\text{NO}_2$ . If necessary, the azabicyclic nitrogen atom may be protected during the reaction by methods well known in the art, e.g. by prior formation of a quaternary derivative such as an N-benzyl derivative. Protection may also  
5 be effected by formation of a borane ( $\text{BH}_3$ ) complex. It will be appreciated that the N-protecting group should be chosen such that it can be removed without affecting other moieties in the molecule. Thus for example a benzyl protecting group may not be appropriate when the side chain  $(\text{CH}_2)_n\text{A}(\text{CH}_2)_m\text{Ar}$  also contains a benzyl moiety such as a benzyloxy group. In general, N-protection is preferred when the leaving group L  
10 represents halogen, e.g. bromine, but when L is a sulphonic acid residue e.g. a tosylate, N-protection may not be necessary.

The reaction between a compound of formula (III) and a compound of formula  $\text{HA}^1(\text{CH}_2)_m\text{Ar}$  (process (b)) can take place under conditions which depend on the nature  
15 of  $\text{L}^1$  and A. For example when  $\text{L}^1$  is hydroxy, m is 0 and  $\text{A}^1$  is oxygen or sulphur the reaction is carried out in the presence of diethyl azodicarboxylate and triphenyl phosphine. Such a reaction is known as the Mitsunobu reaction (as described in Synthesis 1981, 1). Alternatively the leaving group  $\text{L}^1$  may be for example a halogen atom or a sulphonyloxy group eg. methane-sulphonyloxy or p-toluene sulphonyloxy in which case the compound  
20 (III) may preferably be protected, e.g. as an acid salt, such as a hydrochloride salt. Reaction may be effected in the presence or absence of solvent, at a temperature in the range 0 to  $200^\circ\text{C}$  and may preferably be carried out in the presence of a base.

The reduction of a compound of formula (IV) according to process (d) can be effected by  
25 methods known in the art, for example using a reducing agent such as lithium aluminium hydride. Conveniently a compound of formula (IV) can be prepared (for example as described below) and reduced in a 'one-pot' reaction, without isolation of compound (IV) itself.

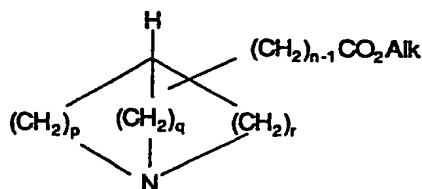
30 The reaction between a compound of formula (V) in process (d) and a compound of formula  $\text{X}^1\text{Ar}$  can take place under standard conditions known to those skilled in the art for the formation of carbon-carbon bonds.

Process (e) may be effected using a Wadsworth-Emmons reagent of the formula  
35  $\text{Ar}(\text{CH}_2)_{m+1}\text{P}(\text{O})(\text{OAlk})_2$ , such as a diethylphosphonate, or a Wittig reagent of the formula  $\text{Ar}(\text{CH}_2)_{m+1}\text{PPh}_3\text{X}$  (where X is an anion) which compounds are available commercially or can be prepared by known methods. The reaction may be carried out in a solvent such as tetrahydrofuran optionally containing a crown ether such as 15-crown-5, or

18-crown-6, and in the presence of a strong base such as sodium hydride or potassium t-butoxide.

Interconversion reactions according to process (f) may be effected by methods well known in the art. Thus for example conversion of a compound (I) wherein A represents -CH=CH- into a compound (I) wherein A represents -CH<sub>2</sub>-CH<sub>2</sub>- may be effected by catalytic reduction.

Compounds of formula (II) wherein n is 1 to 6 and A<sup>1</sup> is oxygen may be prepared by reduction of the corresponding ester of formula (VII) :



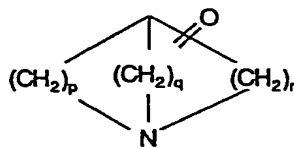
Formula (VII)

wherein p, q and r are as hereinbefore defined and Alk is a C<sub>1-6</sub>alkyl group e.g. ethyl. The reduction may be effected using a reducing agent such as lithium aluminium hydride in a solvent such as diethyl ether or tetrahydrofuran. Esters of formula (VII) wherein n is 1 are described for example in European Patent Applications 257,741 and 392,803 and by B.S. Orlek *et al.* J. Med Chem, 1991, 34, 2726 and Grob *et al.* Helv. Chim. Acta, 1957, 227, 2170. Esters wherein n is greater than 1 may be prepared by conversion of an ester wherein n is 1 to the corresponding N-methyl-N-methoxycarboxamide (e.g. by hydrolysis of the ester followed by reaction with thionyl chloride and N, O-dimethylhydroxylamine hydrochloride), which is then reduced to the aldehyde using diisobutylaluminium hydride. The aldehyde is further converted to the cyanomethyl derivative for example as described in EPA 363,085, followed by acid hydrolysis, and esterification to form an ester wherein n is 2. The sequence may be repeated to form higher homologues.

Homologation may also be effected by the method described in British Patent No. 1250534, starting with a compound (II) wherein A<sup>1</sup> is O and n is 1 and proceeding via the corresponding halomethyl and cyanomethyl derivatives to an ester of formula (VII) wherein n is 2 which may be reduced to an alcohol (II) wherein n is 2.

A further method for the preparation of a compound of formula (II) wherein p, q, r and n each represent 2, A<sup>1</sup> is oxygen and the group (CH<sub>2</sub>)<sub>n</sub>A<sup>1</sup>H is α to the ring nitrogen atom involves cyclisation of a 4-piperidyl-but-2-enoic acid ester e.g. a methyl ester. The cyclisation is an intramolecular Michael reaction which may be carried out at elevated temperature in an inert solvent such as refluxing toluene. Methyl 4-piperidyl-but-2-enoate may be obtained from a suitable N-protected precursor such as methyl 4-(4-N-tert-butylloxycarbonylpiperidyl)-but-2-enoate (which may be prepared as described in EP 478363), using e.g. trifluoroacetic acid optionally in a solvent such as dichloromethane. Reduction e.g. with lithium aluminium hydride provides the above mentioned compound of formula (II).

Alternatively compounds of formula (II) may be prepared by reaction of an aldehyde of formula (VI) or a ketone of formula (VIII) :



Formula (VIII)

with triethylphosphonoacetate or triethylphosphonocrotonate, followed by catalytic hydrogenation to give an ethoxycarbonylalkyl derivative which is further reduced e.g. using lithium aluminium hydride, to the desired hydroxyalkyl compound. It will be appreciated that use of triethylphosphonoacetate results in a 2-carbon homologation whilst triethylphosphonocrotonate gives a 4-carbon homologation.

Compounds of formula (II) wherein n is zero may be prepared by reduction of a compound of formula (VII) e.g. using lithium aluminium hydride.

Ketones of formula (VIII) are commercially available or can be prepared by literature methods, generally via a Dieckmann cyclisation, (for example as described in EPA 94742).

Compounds of formula (II) wherein A<sup>1</sup> is S or NR<sup>1</sup> may be prepared from the corresponding hydroxy compound by standard methods, for example via formation of an alkyl halide followed by reaction with an appropriate amine or thiol.



Compounds of formula (III) wherein  $L^1$  is OH can be prepared as described for compounds of formula (II), and compounds of formula (III) wherein  $L^1$  is a halogen atom, or a mesyloxy or tosyloxy group can be prepared from the corresponding alcohol in conventional manner.

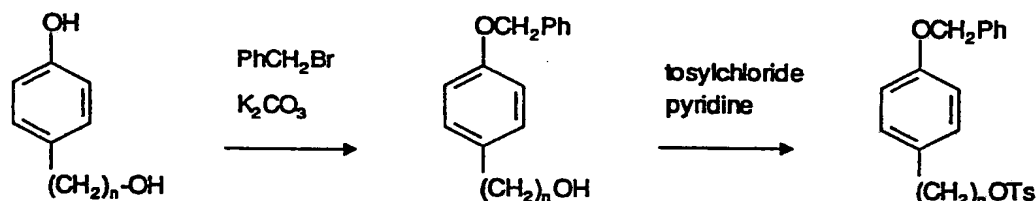
5

The compounds of formula  $L(CH_2)_mAr$  and  $HA^1(CH_2)_mAr$  may be prepared by standard methods well known in the art. For example compounds  $L(CH_2)_mAr$  wherein Ar is a substituted phenyl group and L is halo, e.g. bromo, may be prepared by Friedel-Crafts acylation of the corresponding substituted benzene derivative, using an appropriate acid chloride and catalysed by aluminium trichloride, followed by reduction *in situ* with triethylsilane.

10

When Ar represents a phenyl group substituted by benzyloxy compounds  $L(CH_2)_mAr$  may be prepared according to the following scheme :

15



The starting materials are available commercially or may be prepared by standard methods, e.g. by reaction of 4-benzyloxybenzaldehyde with triethylphosphonocrotonate in a similar manner to that described for the preparation of compounds (II).

20

Compounds of formula (IV) wherein  $R^5$  is a group  $-(CH_2)_nN(R^1)C(O)(CH_2)_{m-1}Ar$  can be prepared by reacting a compound of formula (II) wherein  $A^1$  represents  $NR^1$  with an acylating agent corresponding to the group  $-(CH_2)_mAr$ , for example an acid chloride  $ClOC(CH_2)_{m-1}Ar$ .

25

Compounds of formula (IV) wherein  $R^5$  is a group  $-(CH_2)_{n-1}C(O)N(R^1)(CH_2)_mAr$  may be prepared for example by reaction of a corresponding compound wherein  $R^5$  represents  $-(CH_2)_{n-1}CO_2H$  or an activated derivative thereof such as an acid halide, ester or anhydride, with an amine of formula  $HN(R^1)(CH_2)_mAr$ . It will be appreciated that when the acid itself is employed, reaction with the amine should be effected in the presence of a coupling agent. The carboxylic acid may itself be prepared for example by oxidation of the corresponding alcohol, i.e. a compound of formula (II) wherein  $A^1$  is oxygen.

30

Compounds of formula (V) may be prepared in analogous manner to compounds of formula (III); where necessary the chain length may be increased using methods well known in the art.

5

Compounds of formula (VI) may be prepared by conventional methods, for example the oxidation of a compound of formula (II) wherein A<sup>1</sup> is oxygen, or conversion of the corresponding ester, e.g. by hydrolysis and subsequent reaction with thionyl chloride and N,O-dimethyl-hydroxylamine, followed by reduction of the resulting N-methyl-

10 N-methoxy-carboxamide, using diisobutylaluminium hydride. Compounds of formula (VI) wherein n is 1 may be prepared from the corresponding compound wherein n is zero by various methods. For example the aldehyde wherein n is zero may be treated with (methoxymethyl) triphenylphosphonium chloride and potassium t-butoxide, followed by a strong acid, e.g. concentrated sulphuric acid, resulting in the aldehyde wherein n is 1.

15 Alternatively the aldehyde may be converted to the corresponding cyanomethyl derivative as described in EPA 363085 followed by acid hydrolysis, conversion to the N-methyl-N-methoxycarboxamide and reduction. These procedures may also be used to form higher homologues.

20 When a compound of formula (I) is obtained as a mixture of enantiomers, these may be separated by conventional methods such as crystallisation in the presence of a resolving agent, or chromatography, for example using a chiral HPLC column.

For use in medicine, the compounds of the present invention are usually administered in a  
25 standard pharmaceutical composition. The present invention therefore provides in a further aspect pharmaceutical compositions comprising a novel compound of formula (I) or a pharmaceutically acceptable salt thereof and a pharmaceutically acceptable carrier or excipient.

30 The compounds for use according to the invention may be administered by any convenient method for example by oral, parenteral, buccal, rectal or transdermal administration and the pharmaceutical compositions adapted accordingly.

The compounds of formula (I) and their pharmaceutically acceptable salts which are active  
35 when given orally can be formulated as liquids or solids, for example syrups, suspensions or emulsions, tablets, capsules and lozenges.

A liquid formulation will generally consist of a suspension or solution of the compound or pharmaceutically acceptable salt in a suitable liquid carrier(s) for example, ethanol, glycerine, non-aqueous solvent, for example polyethylene glycol, oils, or water with a suspending agent, preservative, flavouring or colouring agent.

5

A composition in the form of a tablet can be prepared using any suitable pharmaceutical carrier(s) routinely used for preparing solid formulations. Examples of such carriers include magnesium stearate, starch, lactose, sucrose and cellulose.

- 10 A composition in the form of a capsule can be prepared using routine encapsulation procedures. For example, pellets containing the active ingredient can be prepared using standard carriers and then filled into a hard gelatin capsule; alternatively, a dispersion or suspension can be prepared using any suitable pharmaceutical carrier(s), for example aqueous gums, celluloses, silicates or oils and the dispersion or suspension then filled into  
15 a soft gelatin capsule.

- Compounds for use according to the invention may also be administered parenterally, by bolus injection or continuous infusion. Typical parenteral compositions consist of a solution or suspension of the compound or pharmaceutically acceptable salt in a sterile  
20 aqueous carrier or parenterally acceptable oil, for example polyethylene glycol, polyvinyl pyrrolidone, lecithin, arachis oil or sesame oil. Alternatively, the solution can be lyophilised and then reconstituted with a suitable solvent just prior to administration.

- Both liquid and solid compositions may contain other excipients known in the  
25 pharmaceutical art, such as cyclodextrins.

Preferably the composition is in unit dose form such as a tablet, capsule or ampoule.

- Each dosage unit for oral administration contains preferably from 1 to 250 mg (and for  
30 parenteral administration contains preferably from 0.1 to 60 mg) of a compound of the formula (I) or a pharmaceutically acceptable salt thereof calculated as the free base.

- The daily dosage regimen for an adult patient may be, for example, an oral dose of between 1 mg and 500 mg, preferably between 1 mg and 250 mg, eg. 5 to 200 mg or an  
35 intravenous, subcutaneous, or intramuscular dose of between 0.1 mg and 100 mg, preferably between 0.1 mg and 60 mg, eg. 1 to 40 mg of the compound of the formula (I) or a pharmaceutically acceptable salt thereof calculated as the free base, the compound being administered 1 to 4 times per day. Alternatively the compounds of the invention

may be administered by continuous intravenous infusion, preferably at a dose of up to 400 mg per day. Thus the total daily dosage by oral administration will be in the range 1 to 2000 mg and the total daily dosage by parenteral administration will be in the range 0.1 to 400 mg. Suitably the compounds will be administered for a period of continuous  
5 therapy, for example for a week or more.

## BIOLOGICAL DATA

### Ca<sup>2+</sup> Current Measurement

10

#### Cell preparations

Sensory neurons from dorsal root ganglia were dissociated from 1 day old rat pups (Ford et al, Developmental Brain Research, 22 (1985), 55-65). Cells were plated out onto glass coverslips and used within 3 days to permit effective voltage clamp of Ca<sup>2+</sup> currents.

15

#### Solutions

The pipette (internal solution) contained in mM: CsCl, 130; HEPES, 10; EGTA, 10; MgCl<sub>2</sub>, 4; ATP, 2; buffered to pH 7.2 with CsOH. Cells were bathed in a normal Tyrodes solution before establishment of whole cell recording when the bathing solution  
20 was changed to one allowing isolation of Ca<sup>2+</sup> currents. The external solution for recording Ca<sup>2+</sup> channel currents contained in mM: BaCl<sub>2</sub>, 10; TEA-Cl, 130; glucose, 10; HEPES, 10; MgCl<sub>2</sub>, 1; buffered to pH 7.3 with TEA-OH. Barium was used as the charge carrier as this assists in current isolation and calcium dependent inactivation of current is avoided. Compounds were dissolved in DMSO to make a 20 mM stock  
25 solution. At the drug concentration used the vehicle (0.1%) had no significant effect on Ca<sup>2+</sup> currents. All experiments were performed at 21 to 24°C. Whole cell currents were recorded using List EPC-7 amplifiers and stored, digitised for later analysis using PC based software similar to that described previously (Benham & Tsien, Journal of Physiology (1988), 404, 767-784).

30

#### Ca<sup>2+</sup> currents

Peak voltage gated Ca<sup>2+</sup> channel currents of up to 10 nA from dorsal root ganglion neurons were recorded using 10 mM Ba<sup>2+</sup> as charge carrier. Currents were evoked from a holding potential of -80 mV to a test potential of 0 or +10 mV every 15 seconds. This  
35 test potential was at the peak of the current voltage relationship and assessing block at this point reduced any errors due to drifting holding potential. Some cells showed slow rundown of current as is commonly seen when recording Ca<sup>2+</sup> currents. The rundown rate was measured in control conditions and extrapolated through the time of drug

application to derive a control value to relate the drug affected current to. Block by 20 mM drug was assessed 3 minutes after drug application.

Compounds of the invention gave percentage inhibition of plateau  $\text{Ca}^{2+}$  current in the  
5 range 28 - 99%.

**PHARMACEUTICAL FORMULATIONS****1. Formulation for intravenous infusion**

|    |                                    |             |
|----|------------------------------------|-------------|
| 5  | Compound of formula (I)            | 0.1 - 60 mg |
|    | Sodium hydroxide/hydrochloric acid | to pH ca 7  |
|    | polyethylene glycol                | 0 - 30 ml   |
|    | propylene glycol                   | 0 - 30 ml   |
|    | alcohol                            | 0 - 10 ml   |
| 10 | water                              | to 100 ml   |

**2. Formulation for bolus injection**

|    |                                       |             |
|----|---------------------------------------|-------------|
|    | Compound of formula (I)               | 0.1 - 60 mg |
| 15 | sodium hydroxide or hydrochloric acid | to pH ca 7  |
|    | polyethylene glycol                   | 0 - 2.5 ml  |
|    | alcohol                               | 0 - 2.5 ml  |
|    | water                                 | to 5 ml     |

20 A tonicity adjusting agent eg. sodium chloride, dextrose or mannitol may also be added.

**3. Tablet for oral administration**

|    |                            |            |
|----|----------------------------|------------|
|    |                            | mg/tablet  |
| 25 | Compound of formula (I)    | 25         |
|    | lactose                    | 153        |
|    | starch                     | 33         |
|    | crospovidone               | 12         |
|    | microcrystalline cellulose | 30         |
| 30 | magnesium stearate         | <u>2</u>   |
|    |                            | <u>255</u> |

The following non-limiting examples illustrate the preparation of compounds of formula (I) :

**Preparation 1**

5    **(±)3-Hydroxymethyl-1-azabicyclo[2.2.2]octane**

A solution of (±) methyl 1-azabicyclo[2.2.2]oct-3-yl-carboxylate (B.S. Orlek et al., J. Med. Chem., 1991, 34, 2726) (11g, 65mmol) in dry diethyl ether (100ml) was added over 0.5h to a stirred, ice cold suspension of lithium aluminium hydride (4.94g, 130mmol) in  
10    dry diethyl ether (200ml), under nitrogen. The reaction was allowed to warm to room temperature over 20 min and then quenched with wet ether followed by the minimum amount of water. The reaction was filtered and the precipitate was washed with 20% methanol in diethyl ether. The combined filtrate and washings were concentrated *in vacuo* and the resulting clear oil was distilled to afford the title compound as a colourless oil  
15    (7.55g) b.p. 150°C, 0.4mmHg (Kugelröhr) which solidified on standing.

$^1\text{H}$  Nmr ( $\text{CDCl}_3$ )  $\delta$  : 1.33-1.93 (6H, m), 2.27-2.52 (2H, m), 2.68-2.89 (4H, m), 2.94-3.07 (1H, m), 3.57 (2H, d, J=8Hz)

20    **Preparation 2**

**(±) endo-3-hydroxymethyl-1-azabicyclo[2.2.1]heptane**

The title compound was prepared in a similar manner to Preparation 1 from (±) endo ethyl 1-azabicyclo[2.2.1]hept-3-ylcarboxylate (EP392803, Description 21) (2g, 11.8mmol) and  
25    lithium aluminium hydride (0.90g, 23.7mmol). This afforded the title compound as a white solid (1.22g) b.p. 150°C, 0.5mmHg (Kugelöhr).

$^1\text{H}$  Nmr ( $\text{CDCl}_3$ )  $\delta$  : 1.38-1.63 (2H, m) 1.83-2.00 (1H, m), 2.11-2.67 (5H, m), 2.75-3.03 (2H, m), 3.20-3.69 (3H, m).

30

**Preparation 3**

**(±) exo-3-and endo-3-hydroxymethyl-1-azabicyclo[2.2.1]heptane**

The title compound was prepared in a similar manner to Preparation 1 from (±) exo- and  
35    endo-ethyl 1-azabicyclo[2.2.1]hept-3-ylcarboxylate (EP392803, Description 22) (2g, 11.8mmol) and lithium aluminium hydride (0.90g, 23.7mmol). This afforded title compound as a clear oil (1.01g) b.p. 150°C, 0.5mmHg (Kugelröhr) consisting of a 6:1 mixture of exo and endo isomers.

<sup>1</sup>H Nmr (CDCl<sub>3</sub>) (Signals corresponding to the major exo- isomer) δ : 1.11-1.25 (1H, m), 1.53-1.71 (2H, m), 2.17-2.91 (7H, m) 3.28-3.51 (3H, m).

#### 5 Preparation 4

##### (±)3-Formylmethyl-1-azabicyclo[2.2.2]octane

A suspension of potassium tert-butoxide (1.62g, 14.39mmol) in dry tetrahydrofuran (50ml), at -20°C, under nitrogen, was treated with (methoxymethyl)triphenylphosphonium chloride (4.93g, 14.39mmol) over 30 min. After stirring at -20°C for 30 min the reaction was treated with a solution of (±)1-azabicyclo[2.2.2]oct-3-ylcarboxaldehyde (EP363085, Description 32) (1g, 7.19mmol) in tetrahydrofuran (5ml). The reaction was stirred at -20°C for 1h, then quenched by the addition of 5N sulphuric acid (15ml). The separated aqueous layer was washed with chloroform (2x10ml), then cooled in ice and treated dropwise with concentrated sulphuric acid (3ml). After stirring for 1.5h at 0°C, the solution was basified with potassium carbonate, then extracted into chloroform (3x40ml). The combined organic extracts were dried over sodium sulphate then concentrated *in vacuo*. The residue was taken up in diethyl ether, filtered, then concentrated *in vacuo* and distilled to afford the title compound as a clear oil (0.42g) b.p. 175°C, 0.8mmHg (Kugelrohr).

#### Preparation 5

##### (±)3-(2-Hydroxyethyl)-1-azabicyclo[2.2.2]octane

The title compound was prepared in a similar manner to Preparation 1 from (±) 3-ethoxycarbonylmethyl-1-azabicyclo-[2.2.2]octane (EP 363085, Description 3), (8.72g, 44.3mmol) and lithium aluminium hydride (5.04g, 132mmol). This afforded the title compound as a clear oil (4.22g) b.p. 175°C, 0.2mmHg (Kugelrohr).

<sup>1</sup>H Nmr (CDCl<sub>3</sub>) δ : 1.29-1.72 (8H, m), 2.30-2.41 (1H, m), 2.68-2.93 (5H, m), 3.00-3.13 (1H m), 3.55-3.66 (2H, t, J=7Hz).

#### Preparation 6

##### (±) 3-(3-Ethoxycarbonylpropyl)-1-azabicyclo[2.2.2]octane

A solution of 3-quinuclidinone (1.0g, 8.0 mmol) and triethyl 4-phosphonocrotonate (2.50g, 10.0 mmol) in dry tetrahydrofuran (10 ml) was added over 15 min to a stirred ice cold suspension of sodium hydride (0.30g of an 80% dispersion in mineral oil, 10.0 mmol)



in dry tetrahydrofuran (20 ml) containing 15-crown-5 (60 mg) under nitrogen. The reaction was allowed to warm up to room temperature. After 1.5 h further quantities of triethyl 4-phosphonocrotonate (0.625g, 2.5 mmol) and sodium hydride (0.075g of an 80% dispersion in mineral oil, 2.5 mmol) were added, and the mixture was left stirring  
5 overnight. The reaction was quenched with glacial acetic acid (1ml) and concentrated *in vacuo*. The residue was partitioned between aqueous saturated potassium carbonate (30 ml) and chloroform (30 ml). The aqueous phase was further extracted with chloroform (2x30 ml), and the combined organic extracts were dried over sodium sulphate and concentrated *in vacuo*. Treatment with ethereal hydrogen chloride afforded the  
10 hydrochloride salt (2.1g) which was dissolved in ethanol (40 ml) and hydrogenated over 10% Pd-C (0.5g) at atmospheric pressure for 1h. After removal of the catalyst by filtration through kieselguhr the filtrate was concentrated *in vacuo*. The residue was partitioned between saturated aqueous potassium carbonate (25 ml) and chloroform (25 ml). The aqueous layer was extracted with chloroform (2x25ml) and the combined  
15 organic extracts were dried over sodium sulphate and concentrated *in vacuo* to give the title compound as an oil (1.95g) which was used in the next stage without purification.

$^1\text{H Nmr}$  ( $\text{CDCl}_3$ )  $\delta$ : 1.20-1.75 (13H, m), 2.30 (3H, m), 2.80 (4H, m), 3.08 (1H, m), 4.12 (2H, q,  $J=6\text{Hz}$ )

20

#### Preparation 7

##### ( $\pm$ ) 3-(4-Hydroxybutyl)-1-azabicyclo[2.2.2]octane

The title compound was prepared in a similar manner to Preparation 1 from ( $\pm$ ) 3-(3-ethoxycarbonylpropyl)-1-azabicyclo[2.2.2]octane (1.94g) and lithium aluminium hydride  
25 (1.21g, 32 mmol). This afforded the title compound as an oil (1.0g, 68% based on 3-quinuclidinone) which solidified on standing and was used in the next stage without purification.

30  $^1\text{H Nmr}$  ( $\text{CDCl}_3$ )  $\delta$ : 1.22 - 1.78 (13H, m), 2.32 (1H, m), 2.77 (4H, m), 3.07 (1H, m), 3.62 (2H, t,  $J=6\text{Hz}$ )

#### Preparation 8

##### ( $\pm$ ) 3-(2-Ethoxycarbonyl-ethyl)-1-azabicyclo[2.2.2]octane

35

The title compound was prepared in a similar manner to Preparation 6 from ( $\pm$ ) 1-azabicyclo[2.2.2]octan-3-yl carboxaldehyde (EP 363085, Description 32) (1.50g, 10.8 mmol), triethyl phosphonoacetate (2.78 ml, 14.0 mmol), sodium hydride (0.39g of an 80%

dispersion in mineral oil, 13.0 mmol) and 15-crown-5 (0.1g). After 1h at room temperature, the reaction was quenched with glacial acetic acid (1.5ml) and worked up as described in Preparation 6. Hydrogenation in ethanol (40 ml) over 10% Pd-C (0.5g) at atmospheric pressure afforded the title compound as an oil (1.97g, 86%) which was used  
5 in the next stage without purification.

$^1\text{H}$  Nmr ( $\text{CDCl}_3$ )  $\delta$ : 1.28 (3H, t,  $J=6\text{Hz}$ ), 1.30-1.80 (8H, m), 2.20-2.40 (4H, m), 2.80 (4H, m), 3.10 (2H, m), 4.12 (2H, q,  $J=6\text{Hz}$ ).

#### 10 Preparation 9

##### ( $\pm$ ) 3-(3-Hydroxypropyl)-1-azabicyclo[2.2.2]octane hydrochloride

The title compound was prepared in a similar manner to Preparation 1 from ( $\pm$ ) 3-(2-ethoxycarbonyl-ethyl)-1-azabicyclo[2.2.2]octane (1.97g, 9.34 mmol) and lithium  
15 aluminium hydride (1.06g, 27.9 mmol). Purification by flash chromatography on neutral alumina using 0-10% methanol in chloroform as eluant, followed by distillation afforded the title compound as an oil (0.46g, 30%) b.p.  $180^\circ\text{C}$ , 0.2 mmHg (Kugelrohr).

$^1\text{H}$  Nmr ( $\text{CDCl}_3$ )  $\delta$ : 1.28-1.78 (10H, m), 2.35 (1H, m), 2.75 (4H, m), 2.90-3.12 (1H, m and 1H, br s), 3.60 (2H, t,  $J=6\text{Hz}$ ).  
20

#### Preparation 10

##### ( $\pm$ ) 2-(2-Methoxycarbonylmethyl)-1-azabicyclo[2.2.2]octane

25 A solution of methyl 4-(4-N-t-butyloxycarbonylpiperidinyl)-but-2-enoate (EP 478363) (5.0g, 17.67 mmol) in dry dichloromethane (50ml) was treated with trifluoroacetic acid (10ml) and the mixture was stirred at room temperature for 24h. The reaction was concentrated *in vacuo*, cooled in ice and treated with a saturated aqueous solution of potassium carbonate (75ml). After exhaustive extraction with chloroform the combined  
30 organic layers were dried over sodium sulphate and concentrated *in vacuo*. The residue was extracted into diethyl ether, and insoluble impurities removed by filtration. The filtrate was concentrated *in vacuo*. The residue was dissolved in dry toluene (200ml) and heated under reflux in a nitrogen atmosphere for 12h. The reaction was concentrated *in vacuo* and the residue was distilled to give the title compound as a colourless oil (2.8g,  
35 88%) b.p.  $135^\circ\text{C}$  at 0.2 mm Hg (Kugelrohr).

<sup>1</sup>H Nmr (CDCl<sub>3</sub>) δ: 1.10 (1H, m); 1.50 (4H, m); 1.80 (2H, m); 2.45 (1H, dd, J=15Hz and 7Hz); 2.60 (1H, dd, J= 15Hz and 7Hz); 2.73 (1H, m), 2.95 (3H, m); 3.30 (1H, m); 3.68 (3H, s).

5 **Preparation 11**

**(±) 2-(2-Hydroxyethyl)-1-azabicyclo[2.2.2]octane**

The title compound was prepared in a similar manner to Preparation 1 from (+) 2-(2-methoxycarbonyl-methyl)-1-azabicyclo [2.2.2] octane (2.1g, 11.48mmol) and lithium  
10 aluminium hydride (1.74g, 45.90mmol) employing a reaction time of 2h at room temperature. This afforded the title compound as a colourless solid (1.67g, 94%) b.p. 180°C at 0.1 mm Hg (Kugelrohr).

**Preparation 12**

15 **4-[2-(4-Chlorophenyl)ethyl]phenol**

A solution of 4-chloro-4'-hydroxystilbene (5.43g) in ethanol (80ml) was hydrogenated over 5% Pd-C (1.0g) at atmospheric pressure for 1h. Catalyst was removed by filtration through kieselguhr. The filtrate was concentrated *in vacuo* and distilled to give the title  
20 compound as a colourless solid (4.66g, 85%) b.p. 250°C, 0.1 mm Hg (Kugelrohr)

**Preparation 13**

**2-Phenyl-5-hydroxybenzo[b]furan**

25 A solution of 2-phenyl-5-methoxybenzo[b]furan (K K Thomas and M M Bokadia, J Indian Chem. Soc. 1966, 43, 713) (0.5g, 2.23 mmol) in absolute chloroform (4 ml) was treated with trimethylsilyl iodide (0.44 ml, 3.09 mmol) and warmed at 50°C for 48h. A further quantity (0.22ml) of trimethylsilyl iodide was added during this period. The reaction  
30 mixture was diluted with methanol (20 ml), treated with brine (40 ml) and extracted into diethyl ether (2x40ml). The combined extracts were washed with aqueous sodium metabisulphite, followed by brine (40ml) and dried over sodium sulphate. After concentration *in vacuo* the residue was distilled to give the title compound as a colourless solid (0.41g, 88%) b.p. 250°C, 0.1 mm Hg (Kugelrohr).

**Preparation 14****(±) 4-Ethoxycarbonylmethyl-1-azabicyclo[3.3.1]nonane**

To a solution of triethyl phosphonoacetate (2.62ml, 13.19mmol) in dry N, N-dimethyl-  
5 formamide (13ml) cooled to 0°C under nitrogen was added potassium t-butoxide (1.16g, 10.36mmol) portionwise over 30 min. After stirring at 0°C for 45 min the mixture was cooled to -10°C and treated dropwise with a solution of 1-azabicyclo [3.3.1]nonan-4-one (1.3g, 9.42 mmol) in dry N, N-dimethylformamide (7ml). The reaction was allowed to warm to room temperature and after 6 h quenched below 0°C with excess glacial acetic  
10 acid. The mixture was concentrated *in vacuo* and the residue was treated with 2M orthophosphoric acid (30ml), and washed exhaustively with diethyl ether. The aqueous layer was saturated with potassium carbonate and extracted into chloroform (3x30ml). The combined organic extracts were dried over sodium sulphate and concentrated *in vacuo*. The crude product was purified by flash chromatography on neutral alumina using  
15 0-2% methanol in chloroform as eluant. The major faster running component was hydrogenated in ethanol (25 ml) over 5% Pd-C (0.2g) at atmospheric pressure for 4h. The catalyst was removed by filtration through kieselguhr, and the filtrate was concentrated *in vacuo*. The residue was partitioned between aqueous saturated potassium carbonate (15ml) and chloroform (15ml). The aqueous phase was extracted with chloroform  
20 (2x15ml) and the combined organic layers were dried over sodium sulphate and concentrated *in vacuo*. Chromatography on silica using 2-15% methanol in chloroform as eluant afforded the title compound as a clear oil (0.19g).

**Preparation 15****(±) 4-(2-Hydroxyethyl)-1-azabicyclo[3.3.1]nonane**

The title compound was prepared in a similar manner to Preparation 1 from (±) 4-ethoxycarbonylmethyl-1-azabicyclo [3.3.1] nonane (0.18g, 0.86mmol) and lithium  
aluminium hydride (65mg, 1.71mmol). This afforded the title compound as a clear oil  
30 (0.12g, 83%) b.p. 190°C, 0.2mmHg (Kugelrohr).

**Example 1****(±)3-(3,4-Dichlorophenoxymethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E1)**

5 A solution of (±) 3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol) in dry tetrahydrofuran (40 ml), under nitrogen, was treated with 3,4-dichlorophenol (0.867g, 5.32mmol) in dry tetrahydrofuran (2 ml), then treated with triphenylphosphine (1.21g, 4.61mmol) in tetrahydrofuran (2 ml). Diethyl azodicarboxylate (0.80g, 4.61mmol) was added to the reaction over 0.5 h and the mixture was stirred overnight at room  
10 temperature. The reaction was concentrated *in vacuo* treated with saturated aqueous potassium carbonate (25ml), then extracted into chloroform (3x25ml). The combined organic extracts were dried over sodium sulphate, concentrated *in vacuo* and the residue chromatographed on neutral alumina in a gradient of 0-2% methanol in chloroform. The gum produced was converted to the HCl salt, which was washed thoroughly with diethyl  
15 ether then crystallised to afford the title compound as a white solid (0.78g) m.p. 194-197°C (from methanol - diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.61-2.12 (5H, m), 2.38-2.54 (1H, m), 2.83-2.94 (1H, m), 3.04-3.45 (5H, m), 4.10 (2H, d, J=Hz), 6.98 (1H, dd, J=4, 9Hz), 7.28 (1H, d, J=4Hz), 7.53  
20 (1H, d, J=9Hz).

**Example 2****(±)3-(4-Benzyloxyphenoxymethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E2)**

25 The title compound was prepared in a similar manner to Example 1 from (±)3-hydroxymethyl-1-azabicyclo[2.2.2]octane (2g, 14.2mmol), 4-(benzyloxy)phenol (8.52g, 42.6mmol), triphenylphosphine (4.84g, 18.4mmol) and diethyl azodicarboxylate (3.21g, 18.4mmol). This afforded the title compound as a white solid (3g) m.p. 205-207°C (from  
30 methanol-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.64-2.13 (5H, m), 2.38-2.52 (1H, m), 2.83-2.91 (1H, m), 3.07-3.46 (5H, m), 3.98 (2H, d, J=8Hz), 5.05 (2H, s), 6.86-6.99 (4H, m), 7.28-7.46  
35 (5H, m)

**Example 3****(±)3-(4-Benzylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E3)**

5 The title compound was prepared in a similar manner to Example 1 from (±)3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 4-hydroxydiphenylmethane (0.98g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.80g, 4.61mmol). This afforded the title compound as a white solid (0.46g) m.p. 169-171°C (methanol-diethyl ether).

10

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.60-2.12 (5H, m), 2.36-2.51 (1H, m), 2.80-2.92 (1H, m), 3.08-3.45 (5H, m), 3.85 (2H, s), 3.99 (2H, d, J=7Hz), 6.79-6.92 (2H, m), 7.07-7.31 (7H, m)

15

**Example 4****(±)3-(2-Phenylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E4)**

20 The title compound (E4) was prepared in a similar manner to Example 1 from (±)3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 2-phenylphenol (0.905g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.80g, 4.61mmol). This afforded the title compound as a white solid (0.49g) m.p. 184-187°C (from methanol-diethyl ether).

25 <sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.64-2.11 (5H, m), 2.42-2.57 (1H, m), 2.95-3.54 (6H, m), 4.16 (2H, d, 7Hz), 7.09-7.62 (9H, m).

**Example 5****(±)3-(4-tert-Butylphenoxyethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E5)**

30 The title compound was prepared in a similar manner to Example 1 from (±)3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 4-tert-butylphenol (0.80g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.80g, 4.61mmol). This afforded the title compound (E5) as a white solid (0.35g) m.p. 276-279°C (from methanol-diethyl ether).

$^1\text{H}$  Nmr (DMSO- $d_6$ )  $\delta$  : 1.24 (9H, s), 1.63-2.15 (5H, m), 2.39-2.53 (1H, m), 2.83-2.94 (1H, m), 3.08-3.47 (5H, m), 4.02 (2H, d,  $J=7\text{Hz}$ ), 6.88 (2H, d,  $J=8\text{Hz}$ ), 7.30 (2H, d,  $J=8\text{Hz}$ )

5

**Example 6****( $\pm$ )3-(1-Naphthyloxymethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E6)**

The title compound was prepared in a similar manner to Example 1 from ( $\pm$ )3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 1-naphthol (0.77g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.80g, 4.61mmol). This afforded the title compound as a white solid (0.18g) m.p. 206-208°C (from methanol-diethyl ether).

$^1\text{H}$  Nmr (DMSO- $d_6$ )  $\delta$  : 1.60-1.72 (1H, m), 1.77-2.01 (3H, m), 2.11-2.20 (1H, m), 2.53-2.66 (1H, m), 2.89-3.01, (1H, m), 3.05-3.32 (4H, m), 3.41-3.53 (1H, m), 4.18 (2H, d,  $J=7\text{Hz}$ ), 6.95 (1H, d,  $J=7\text{Hz}$ ), 7.29-7.52 (4H, m), 7.75-7.84 (1H, m), 8.02-8.10 (1H, m).

20

**Example 7****( $\pm$ )3-(2-Dibenzofuranyloxymethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E7)**

The title compound was prepared in a similar manner to Example 1 from ( $\pm$ )3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 2-hydroxy-dibenzofuran (0.98g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.81g, 4.61mmol). The crude product was purified on neutral alumina in a gradient of 0-2% methanol in toluene. Pooling of fractions containing the faster running component afforded a gum which was treated with ethereal hydrogen chloride to give the title compound as a white solid (0.29g) m.p. 246-247°C (from methanol-diethyl ether).

30

$^1\text{H}$  Nmr (DMSO- $d_6$ )  $\delta$  : 1.68-2.08 (4H, m), 2.13-2.19 (1H, m), 2.47-2.59 (1H, m), 2.92-3.00 (1H, m), 3.11-3.49 (5H, m), 4.18 (2H, d, 8Hz), 7.13 (1H, dd,  $J=2, 7\text{Hz}$ ), 7.38 (1H, t,  $J=7\text{Hz}$ ), 7.51 (1H, t,  $J=7\text{Hz}$ ), 7.52 (1H, d,  $J=7\text{Hz}$ ), 7.56 (1H, d,  $J=7\text{Hz}$ ), 7.77 (1H, d,  $J=2\text{Hz}$ ), 8.12 (1H, d,  $J=7\text{Hz}$ )

35

**Example 8****(±)3-(5-Isoquinolinylloxy)methyl-1-azabicyclo[2.2.2]octane hydrochloride (E8)**

5 The title compound was prepared in a similar manner to Example 1 from (±)3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 5-hydroxyisoquinoline (0.72g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.8g, 4.61mmol). This afforded the title compound as a white solid (0.19g) m.p. 277-280°C (from methanol-diethyl ether).

10

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.73-2.18 (4H, m), 2.27-2.36 (1H, m), 2.71-2.86 (1H, m), 3.04-3.45 (5H, m), 3.55-3.70 (1H, m), 4.46 (2H, d, 7Hz), 7.74 (1H, d, J=7Hz), 8.02 (1H, t, J=7Hz), 8.16 (1H, d, J=7Hz), 8.56 (1H, d, J=6Hz), 8.74 (1H, d, J=6Hz), 9.92 (1H, s)

15

**Example 9****(±) endo-3-(4-Benzylphenoxymethyl)-1-azabicyclo[2.2.1]heptane hydrochloride (E9)**

20 The title compound was prepared in a similar manner to Example 1 from (±)endo-3-hydroxymethyl-1-azabicyclo[2.2.1]heptane (0.5g, 3.94mmol), 4-hydroxydiphenylmethane (1.09g, 5.91mmol), triphenylphosphine (1.34g, 5.12mmol) and diethyl azodicarboxylate (0.89g, 5.12mmol). This afforded the title compound as a white solid (0.77g) m.p. 153-156°C (from methanol-acetone-diethyl ether).

25 <sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.83-1.93 (2H, m), 2.74-2.95 (3H, m), 3.11-3.39 (4H, m), 3.45-3.53 (1H, m), 3.90 (2H, s), 3.99-4.11 (2H, s), 6.85-6.92 (2H, m), 7.12-7.32 (7H, m).

**Example 10**

30 **(±) endo-3-(4-Benzylloxyphenoxymethyl)-1-azabicyclo[2.2.1]heptane hydrochloride (E10)**

The title compound was prepared in a similar manner to Example 1 from (±)endo-3-hydroxymethyl-1-azabicyclo[2.2.1]heptane (0.5g, 3.94mmol), 4-benzylloxyphenol (1.18g, 5.91mmol), triphenylphosphine (1.34g, 5.12mmol) and diethyl azodicarboxylate (0.89g, 5.12mmol). This afforded the title compound as a white solid (0.31g) m.p. 156-158°C (from methanol-acetone-diethyl ether).

35



$^1\text{H}$  Nmr ( $\text{CDCl}_3$ )  $\delta$  : 1.99-2.16 (2H, m), 2.86-2.97 (2H, m), 3.07-3.25 (3H, m), 3.28-3.36 (1H, m), 3.52-3.62 (1H, m), 3.68-3.78 (1H, m), 3.93-3.99 (1H, m), 4.03-4.08 (1H, m), 5.04 (2H, m), 6.78-6.85 (2H), 6.87-6.94 (2H, m), 7.26-7.44 (5H, m).

5

**Example 11**

**( $\pm$ ) exo-3-(4-Benzylphenoxyethyl)-1-azabicyclo[2.2.1]heptane hydrochloride (E11)**

The title compound was prepared in a similar manner to Example 1 from ( $\pm$ )exo- and  
10 endo-3-hydroxymethyl-1-azabicyclo[2.2.1]heptane (0.5g, 3.94mmol),  
4-hydroxydiphenylmethane (1.09g, 5.91mmol), triphenylphosphine (1.34g, 5.12mmol)  
and diethyl azodicarboxylate (0.89g, 5.12mmol). The crude product was chromatographed  
on silica in a gradient of 0-20% methanol in chloroform. Pooling of pure fractions  
containing the major faster running component gave a gum which was converted into the  
15 hydrochloride salt to afford the title compound as a white solid (0.5g) m.p. 145-148°C  
(from methanol-acetone-diethyl ether).

$^1\text{H}$  Nmr ( $\text{DMSO}-d_6$ )  $\delta$  : 1.62-1.72 (1H, m), 1.95-2.05 (1H, m), 2.32-2.42 (1H, m),  
2.78-2.83 (1H, m), 2.93-3.08 (2H, m), 3.14-3.23 (1H, m), 3.26-3.43 (3H, m), 3.84-3.94  
20 (3H, m), 3.97-4.03 (1H, m), 6.84-6.90 (2H, m), 7.12-7.32 (7H, m).

**Example 12**

**( $\pm$ ) exo-3-(4-Benzoyloxyphenoxyethyl)-1-azabicyclo[2.2.1]heptane hydrochloride  
25 (E12)**

The title compound was prepared in a similar manner to Example 1 from ( $\pm$ )exo- and  
endo-3-hydroxymethyl-1-azabicyclo[2.2.1]heptane (0.5g, 3.94mmol), 4-benzoyloxyphenol  
(1.18g, 5.91mmol), triphenylphosphine (1.34g, 5.12mmol) and diethyl azodicarboxylate  
30 (0.89g, 5.12mmol). The crude product was chromatographed on silica in a gradient of 5-  
20% methanol in chloroform. Pooling of pure fractions containing the major faster  
running component gave a gum which was converted into the hydrochloride salt to afford  
the title compound as a white solid (0.29g) m.p. 156-158°C (from methanol-acetone-  
diethyl ether).

35

$^1\text{H}$  Nmr ( $\text{DMSO}-d_6$ )  $\delta$  : 1.72-1.87 (1H, m), 2.05-2.12 (1H, m), 2.43-2.58 (1H, m), 2.93-  
2.98 (1H, m), 3.06-3.50 (6H, m), 3.94-4.16 (2H, m), 5.20 (2H, m), 6.95-7.17 (4H, m),  
7.42-7.65 (5H, m).

**Example 13****(±) E-3-[2-(1-Naphthyl)ethenyl]-1-azabicyclo[2.2.2]octane hydrochloride (E13)**

5

A solution of 1-azabicyclo[2.2.2]oct-3-yl carboxaldehyde (EP363085, Description 32) (1g, 7.19mmol) and diethyl 1-naphthylmethylphosphonate (2g, 7.19mmol) in tetrahydrofuran (10ml) was added over 10 min to an ice cold slurry of sodium hydride (0.216g of an 80% dispersion in mineral oil, 7.19mmol) and 15-crown-5 (60mg) in tetrahydrofuran (20ml) under nitrogen (R. Baker et al., Synthesis, 1981, 117). The mixture was allowed to warm to room temperature and stirred for 2 h. The reaction was quenched by the addition of acetic acid (1ml), then concentrated *in vacuo*. The residue was treated with saturated aqueous potassium carbonate (25ml) then extracted into chloroform (3 x 25ml). The combined organic extracts were dried over sodium sulphate, concentrated *in vacuo* and the residue chromatographed on neutral alumina in a gradient of 0-2% methanol in chloroform. The gum produced was converted into the HCl salt, which was washed thoroughly with diethyl ether then crystallised to afford the title compound as a white solid (1.4g) m.p. 196-198°C (from methanol-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.74-2.28 (5H, m), 3.00-3.74 (7H, m), 6.58 (1H, dd, J=7, 15Hz), 7.50 (1H, d, J=15Hz), 7.55-8.12 (6H, m), 8.25-8.32 (1H, m).

**Example 14****(±)E-3-[2-(4-Biphenyl)ethenyl]-1-azabicyclo[2.2.2]octane hydrochloride (E14)**

The title compound was prepared in a similar manner to Example 13 from 1-azabicyclo[2.2.2]oct-3-yl-carboxaldehyde (0.78g, 5.61mmol), diethyl 4-biphenylmethylphosphonate (1.70g, 5.61mmol), sodium hydride (0.17g of an 80% dispersion in mineral oil, 5.61mmol) and 15-crown-5 (60mg). This afforded the title compound as a white solid (1.3g) m.p. 289-290°C (from methanol-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.57-1.69 (1H, m), 1.75-1.98 (4H, m), 2.75-2.84 (1H, m), 2.94-3.29 (5H, m), 3.35-3.43 (1H, m), 6.39 (1H, dd, J=8, 16Hz), 6.52 (1H, d, J=16Hz), 7.22-7.61 (9H, m).

**Example 15****(±)3-[2-(1-Naphthyl)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E15)**

- 5 A mixture of (±)E-3-[2-(1-naphthyl)ethenyl]-1-azabicyclo[2.2.2]octane hydrochloride (0.7g, 2.34mmol) and 10% Pd-C (70mg) in methanol (25ml) was stirred at room temperature for 2 h under an atmosphere of hydrogen. The reaction was filtered, then concentrated *in vacuo*. The residue was treated with saturated aqueous potassium carbonate (25ml) and extracted into chloroform (3 x 25ml). The combined organic  
10 extracts were dried over sodium sulphate then concentrated *in vacuo*. The gum produced was converted into the HCl salt to afford the title compound as white solid (0.415g) m.p. 169-171°C (from acetone-diethyl ether).

- <sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.63-2.13 (8H, m), 2.76-2.85 (1H, m), 2.97-3.25 (6H, m), 3.38-  
15 3.47 (1H, m), 7.38-3.47 (1H, m), 7.38-7.59 (4H, m), 7.79 (1H, d, J=7Hz), 7.94 (1H, d, J=8Hz), 8.09 (1H, d, J=7Hz).

**Example 16**

- 20 **(±)3-[2-(4-Biphenyl)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E16)**

- The title compound was prepared in a similar manner to Example 15 from (±)E-3-[2-(4-Biphenyl)ethenyl]-1-azabicyclo[2.2.2]octane hydrochloride (E14) (0.65g, 2mmol) and 10%Pd-C (65mg). This afforded the title compound as a white solid (0.14g) m.p. 236-  
25 238°C (from methanol-acetone-diethyl ether).

- <sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.52-1.91 (8H, m), 2.45-2.54 (2H, m), 2.62-2.72 (1H, m), 2.93-  
3.14 (4H, m), 3.22-3.32 (1H, m), 7.18-7.26 (3H, m), 7.31-7.38 (2H, m), 7.45-7.56 (4H, m).

30

**Example 17****(±)E-3-[3-(1-Naphthyl)prop-2-enyl]-1-azabicyclo[2.2.2]octane hydrochloride (E17)**

- 35 The title compound was prepared in a similar manner to Example 13 from (±)3-formylmethyl-1-azabicyclo[2.2.2]octane (0.41g, 2.68mmol), diethyl 1-naphthylmethylphosphonate (0.75g, 2.68mmol), sodium hydride (80mg of an 80% dispersion in mineral

oil, 2.68mmol) and 15-crown-5 (30mg). This afforded the title compound as a white solid (0.47g) m.p. 174-177°C (from methanol-acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.62-2.25 (6H, m), 2.35-2.54 (2H, m), 2.78-2.90 (1H, m), 3.01-3.48 (5H, m), 6.24 (1H, dt, J=7, 15Hz), 7.32 (1H, d, J=15Hz), 7.43-7.68 (4H, m), 7.78-7.96 (2H, m), 8.14-8.25 (1H, m).

#### Example 18

(±)3-[3-(1-Naphthyl)propyl]-1-azabicyclo[2.2.2]octane hydrochloride (E18)

The title compound was prepared in a similar manner to Example 15 from (±)E-3-[3-(1-Naphthyl)prop-2-enyl]-1-azabicyclo[2.2.2]octane hydrochloride (E17) (0.23g, 7.34mmol) and 10%Pd-C (20mg). This afforded the title compound as a white solid (0.16g) m.p.155°C (dec) (from methanol-acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.47-2.22 (10H, m), 2.73-2.92 (1H, m), 3.05-3.58 (7H, m), 7.42-7.74 (4H, m), 7.82-8.26 (3H, m).

#### Example 19

(±)3-[2-(2-Dibenzofuranyloxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E19)

The title compound was prepared in a similar manner to Example 1 from (±)3-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.23mmol), 2-hydroxydibenzofuran (0.89g, 4.84mmol), triphenylphosphine (1.01g, 4.19mmol) and diethyl azodicarboxylate (0.73g, 4.19mmol). This afforded the title compound as a white solid (0.62g m.p 235-237°C (methanol-acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.62-2.06 (7H, m), 2.15-2.28 (1H, m), 2.80-2.94 (1H, m), 3.05-3.52 (5H, m), 4.11 (2H, t, J=6Hz), 7.09 (1h, dd, J=2,8Hz), 7.35-7.79 (5H, m), 8.12 (1H,d, J=8Hz).

**Example 20****(±)3-[2-(4-Benzoyloxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E20)**

5 The title compound was prepared in a similar manner to Example 1 from (±)3-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.23mmol), 4-benzoyloxyphenol (1g, 4.84mmol), triphenylphosphine (1.01g, 4.19mmol) and diethyl azodicarboxylate (0.73g, 4.19mmol). This afforded the title compound as a white solid (0.5g) m.p. 215-216°C (from methanol-acetone-diethyl ether).

10

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.57-1.98 (7H, m), 2.04-2.21 (1H, m), 2.73-2.85 (1H, m), 3.00-3.40 (5H, m), 3.89 (2H, t, J=6Hz), 5.01 (2H, s), 6.79-6.96 (4H, m), 7.24-7.43 (5H, m).

**Example 21**

15

**(±)3-[2-(4-Benzylphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E21)**

The title compound was prepared in a similar manner to Example 1 from (±)3-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.23mmol), 4-hydroxydiphenylmethane (0.89g, 4.84mmol), triphenylphosphine (1.01g, 4.19mmol), and diethyl azodicarboxylate (0.73g, 4.19mmol). This afforded the title compound as a white solid (0.69g) m.p 186-188°C (from methanol-acetone-diethyl ether).

20

<sup>1</sup>H Nmr(DMSO-d<sub>6</sub>) δ : 1.68-2.10 (7H, m), 2.15-2.34 (1H, m), 2.83-2.98 (1H, m), 3.10-3.58 (5H, m), 3.95 (2H, s), 4.03 (2H, t, J=7Hz), 6.82-6.93 (2H, m), 7.17-7.42 (7H, m).

25

**Example 22****(±)3-(4-Phenoxyphenoxymethyl)-1-azabicyclo[2.2.2]octane hydrochloride (E22)**

30

The title compound was prepared in a similar manner to Example 1 from (±)3-hydroxymethyl-1-azabicyclo[2.2.2]octane (0.5g, 3.55mmol), 4-phenoxyphenol (0.99g, 5.32mmol), triphenylphosphine (1.21g, 4.61mmol) and diethyl azodicarboxylate (0.80g, 4.61mmol). This afforded the title compound as a white solid (0.59g) m.p 176-178°C (methanol-acetone-diethyl ether).

35

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ : 1.62-2.03 (4H, m), 2.07-2.14 (1H, m), 2.40-2.55 (1H, m), 2.86-2.96 (1H, m), 3.07-3.48 (5H, m), 4.05 (2H, d, J=7Hz), 6.98-7.11 (7H, m), 7.28-7.40 (2H, m).

5

**Example 23****(±) 3-[2-(4-Phenoxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E23)**

The title compound was prepared in a similar manner to Example 1 from (±) 3-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.22mmol), 4-phenoxyphenol (0.90g, 4.84 mmol), triphenylphosphine (1.0g, 4.19 mmol) and diethyl azodicarboxylate 0.66 ml, 4.19 mmol). After stirring at room temperature for 2h, the reaction was concentrated *in vacuo*. The residue was extracted into diethyl ether, and treated with ethereal hydrogen chloride. The resulting hydrochloride salt was washed with diethyl ether and recrystallised to give the title compound as a colourless solid (0.7g) m.p. 182-185°C (from methanol-acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.70-2.13 (7H, m, overlapping signals), 2.28 (1H, m), 2.95 (1H, m), 3.12-3.55 (6H, m), 4.07 (2H, t, J=7Hz), 6.94-7.20 (7H, m), 7.45 (2H, t, J=7Hz)

20

**Example 24****(±) 3-[4-(2-Dibenzofuranyloxy)butyl]-1-azabicyclo[2.2.2]octane hydrochloride (E24)**

The title compound was prepared in a similar manner to Example 1 from (±) 3-(4-hydroxybutyl)-1-azabicyclo[2.2.2]octane (0.5g, 2.73 mmol), 2-hydroxydibenzofuran (0.75g, 4.09 mmol), triphenylphosphine (0.93g, 3.55 mmol) and diethyl azodicarboxylate (0.56 ml, 3.55 mmol). After stirring at room temperature for 1h the reaction was concentrated *in vacuo*. The crude product was converted into the hydrochloride salt, washed with diethyl ether, then partitioned between saturated aqueous potassium carbonate (25 ml) and chloroform (25 ml). The aqueous layer was further extracted with chloroform (2x25 ml), and the combined organic extracts were dried over sodium sulphate and concentrated *in vacuo*. Flash chromatography on alumina using 0.5-2% methanol in toluene as eluant, followed by treatment with ethereal hydrogen chloride afforded the title compound as a colourless solid (0.31g) m.p. 242-244°C (from methanol-diethyl ether).

35

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.25-2.10 (12H, m, overlapping signals), 2.69 (1H, m), 2.94-3.50 (5H, m, overlapping signals), 4.08 (2H, t, J=7Hz), 7.08 (1H, dd, J=7Hz, 2Hz), 7.28-7.78 (5H, m, overlapping signals), 8.13 (1H, d, J=7Hz).

5

**Example 25****(±) 3-[4-(4-Phenoxyphenoxy)butyl]-1-azabicyclo[2.2.2]octane hydrochloride (E25)**

The title compound was prepared in a similar manner to Example 1 from (±) 3-(4-  
10 hydroxybutyl)-1-azabicyclo [2.2.2]octane (0.5g, 2.73 mmol), 4-phenoxyphenol (0.76g, 4.09 mmol), triphenylphosphine (0.93g, 3.55 mmol) and diethyl azodicarboxylate (0.56ml, 3.55 mmol). After stirring at room temperature for 1h the reaction was worked up as described in Example 24. Purification by chromatography on neutral alumina using 0-2% methanol in chloroform as eluant, followed by treatment with ethereal hydrogen chloride  
15 afforded the title compound as a colourless solid (0.35g) m.p. 151-153°C (from methanol-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.35-2.16 (12H, m, overlapping signals), 2.78 (1H, m), 3.10-3.60 (5H, m, overlapping signals), 4.03 (2H, t, J=7Hz), 6.89-7.22 (7H, m), 7.43 (2H, m).

20

**Example 26****(±) 3-[3-(4-Phenoxyphenoxy)propyl]-1-azabicyclo[2.2.2]octane hydrochloride (E26)**

The title compound was prepared in a similar manner to Example 1 from (±)3-(3-  
25 hydroxypropyl)-1-azabicyclo[2.2.2]octane (0.45g, 2.66 mmol), 4-phenoxyphenol (0.74g, 3.98 mmol), triphenylphosphine (0.91g, 3.47 mmol) and diethyl azodicarboxylate (0.55 ml, 3.47 mmol). After stirring at room temperature for 1h the reaction was worked up as described in Example 24. Purification by chromatography on neutral alumina using 0-2% methanol in chloroform as eluant, followed by treatment with ethereal hydrogen chloride  
30 afforded the title compound as a colourless solid (0.7g) m.p. 149-151°C (from methanol-acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.54-2.20 (10H, m, overlapping signals), 2.80 (1H, m), 3.10-3.60  
35 (5H, m, overlapping signals), 4.05 (2H, t, J=7Hz), 6.90-7.28 (7H, m), 7.43 (2H, t, J=8Hz)

**Example 27****(±) 3-[2-[4-(2-Phenylethyl)phenoxy]ethyl]-1-azabicyclo [2.2.2]octane hydrochloride (E27)**

5 The title compound was prepared in a similar manner to Example 1 from (±) 3-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.23 mmol), *trans* 4-hydroxystilbene (0.95g, 4.84 mmol), triphenylphosphine (1.1g, 4.19 mmol) and diethyl azodicarboxylate (0.66 ml, 4.19 mmol). After stirring at room temperature for 1.5h the reaction was  
10 concentrated *in vacuo*. The residue was extracted into diethyl ether and treated with ethereal hydrogen chloride to give the hydrochloride salt which was washed with diethyl ether. A solution of this salt in ethanol (40 ml) was hydrogenated over 10% Pd-C (0.25g) at atmospheric pressure for 4h. After removal of the catalyst by filtration through kieselguhr, the filtrate was concentrated *in vacuo*. The residue was partitioned between  
15 saturated aqueous potassium carbonate (30 ml) and chloroform (25 ml). The aqueous phase was further extracted with chloroform (2x25 ml), and the combined organic extracts were dried over sodium sulphate and concentrated *in vacuo*. Purification by chromatography on neutral alumina using 0-2% methanol in chloroform as eluant afforded an oil which was treated with ethereal hydrogen chloride to give the title compound as a  
20 colourless solid (0.67g) m.p. 210-212°C (from methanol-acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.55-2.05 (7H, m), 2.16 (1H, m), 2.82 (4H, m), 3.15 (4H, m), 3.38 (2H, m), 3.94 (2H, t, J=7Hz), 6.82 (2H, t, J=8Hz), 7.03-7.36 (7H, m).

25

**Example 28****(±) 3-[2-[4-[2-(4-Chlorophenyl)ethyl]phenoxy]ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E28)**

30 The title compound was prepared in a similar manner to Example 1 from (±) 3-(2-hydroxyethyl)-1-azabicyclo [2.2.2]octane (0.5g, 3.22 mmol), 4-[2-(4-chlorophenyl)ethyl]phenol (1.13g, 4.86 mmol), triphenylphosphine (1.10g, 4.20 mmol) and diethyl azodicarboxylate (0.66 ml, 4.20 mmol). The reaction was worked up as described in Example 24. Purification by chromatography on neutral alumina using 0-2%  
35 methanol in chloroform as eluant followed by treatment with ethereal hydrogen chloride afforded the title compound as a colourless solid (0.56 g) m.p. 220-222°C (from methanol-acetone-diethyl ether).



<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.55-2.00 (7H, m), 2.16 (1H, m), 2.82 (4H, m), 3.15 (4H, m), 3.37 (2H, m), 3.95 (2H, t, J=7Hz), 6.82 (2H, d, J=7Hz), 7.10 (2H, d, J=7Hz), 7.22 (2H, d, J=7Hz), 7.30 (2H, d, J=7Hz)

5

**Example 29**

**(±) 3-[2-[5-(2-Phenyl)benzo[b]furanyloxy]ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E29)**

- 10 The title compound was prepared in a similar manner to Example 1 from (±) 3-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.25g, 1.61 mmol), 5-hydroxy-2-phenylbenzo[b]furan (0.48g, 2.42 mmol), triphenylphosphine (0.59g, 2.25 mmol) and diethyl azodicarboxylate (0.36ml, 2.25 mmol). The reaction was worked up as described in
- 15 Example 24. Purification by chromatography on neutral alumina using 0-2% methanol in chloroform as eluant followed by treatment with ethereal hydrogen chloride afforded the title compound as a colourless solid (0.35g), m.p. 266-267°C (from methanol-acetone-diethyl ether).

- 20 <sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.70-2.15 (7H, m), 2.30 (1H, m), 2.95 (1H, m), 3.14-3.62 (5H, m), 4.13 (2H, t, J=7Hz), 7.00 (1H, dd, J=7Hz, 2Hz), 7.27 (1H, d, J=2Hz), 7.40-7.68 (5H, m), 8.00 (2H, d, J=7Hz).

**Example 30**

- 25 **(±) 2-[2-(4-Benzylphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E30)**

- The title compound was prepared in a similar manner to Example 1 from (±) 2-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (23mg, 0.15 mmol), 4-hydroxydiphenylmethane (41mg, 0.22 mmol), triphenylphosphine (59 mg, 0.22 mmol) and diethyl azodicarboxylate
- 30 (39 mg, 0.22 mmol). After stirring at room temperature for 6h the reaction mixture was concentrated *in vacuo*. The residue was partitioned between water (5 ml) and chloroform (5ml) and the pH of the aqueous phase was adjusted to 12 with potassium carbonate. After further extraction with chloroform (3x5ml) the combined organic layers were dried over
- 35 sodium sulphate and concentrated *in vacuo*. Chromatography on neutral alumina using 0-5% ethanol in chloroform as eluant, followed by treatment with ethereal hydrogen chloride afforded the hydrochloride salt which was washed with diethyl ether and recrystallised to give the title compound as a colourless solid (34 mg) m.p. 177-178.5°C (from acetone-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.50 (1H, m), 1.73 (4H, m), 1.95-2.13 (3H, m), 2.32 (1H, m), 3.07-3.40 (4H, m), 3.57 (1H, m), 3.87 (2H, s), 4.05 (1H, m), 6.86 (2H, d, J=7Hz), 7.10-7.30 (7H, m).

5

### Example 31

**(±) 2-[2-(4-Benzyloxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E31)**

10 The title compound was prepared in a similar manner to Example 30 from (±) 2-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.22mmol), 4-benzyloxyphenol (0.97g, 4.84mmol), triphenylphosphine (1.27g, 4.84mmol) and diethyl azodicarboxylate (0.76ml, 4.84mmol). This afforded the title compound as a colourless solid (0.69g) m.p. 238-240°C (from acetone-diethyl ether).

15

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.70 (1H, m), 1.96 (4H, m), 2.19 (3H, m), 2.50 (1H, m), 3.28 (1H, m), 3.45 (3H, m), 3.74 (1H, m), 4.19 (2H, m), 5.22 (2H, s), 7.10 (4H, q, J=9Hz), 7.58 (5H, m), 10.47 (1H, br.s).

20

### Example 32

**(±) 2-[2-(4-Phenoxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane hydrochloride (E32)**

25 The title compound was prepared in a similar manner to Example 30 from (±) 2-(2-hydroxyethyl)-1-azabicyclo[2.2.2]octane (0.5g, 3.22mmol), 4-phenoxyphenol (0.90g, 4.84mmol), triphenylphosphine (1.27g, 4.84mmol) and diethyl azodicarboxylate (0.76ml, 4.84mmol). This afforded the title compound as a colourless solid (0.74g) m.p. 200-202°C (from acetone-diethyl ether)

30 <sup>1</sup>H Nmr (CDCl<sub>3</sub>) δ: 1.70 (2H, m), 1.93 (4H, m), 2.08 (1H, m), 2.26 (2H, m), 2.82 (1H, m), 3.37 (4H, m), 3.53 (1H, m), 4.18 (2H, m), 6.95 (7H, m), 7.30 (2H, m), 12.02 (1H, br.s).

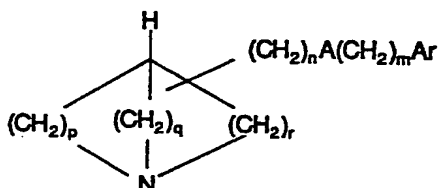
**Example 33****(±) 4-[2-(4-Phenoxyphenoxy)ethyl]-1-azabicyclo[3.3.1]nonane hydrochloride (E33)**

- 5 The title compound was prepared in a similar manner to Example 1 from (±) 4-(2-hydroxyethyl)-1-azabicyclo[3.3.1]nonane (0.11g, 0.65 mmol), 4-phenoxyphenol (0.18g, 0.98 mmol), triphenylphosphine (0.22g, 0.85 mmol) and diethyl azodicarboxylate (0.13 ml, 0.85 mmol). After stirring at room temperature for 2h the reaction was worked up as described in Example 1 to give the title compound as a colourless solid m.p. 195-197°C
- 10 (methanol-diethyl ether).

<sup>1</sup>H Nmr (DMSO-d<sub>6</sub>) δ: 1.53-2.30 (10H, m), 3.05-3.60 (6H, m), 4.00 (2H, t, J=7Hz), 6.83-7.20 (7H, m), 7.35 (2H, t, J=7Hz).

**Claims :**

1. Use of a compound of formula (I):

**Formula (I)**

in which

p, q and r each independently represent an integer from 1 to 4;

A is a bond,  $-\text{CH}=\text{CH}-$ ,  $-\text{C}\equiv\text{C}-$ , oxygen, sulphur or  $\text{NR}^1$ , where  $\text{R}^1$  is hydrogen,  $\text{C}_1$ -alkyl or phenyl $\text{C}_1$ -alkyl;

n is 0 to 6, and m is 0 to 6, such that the length of the chain  $(\text{CH}_2)_n\text{A}(\text{CH}_2)_m$  is at least two atoms; and

Ar is aryl or heteroaryl, each of which may be optionally substituted;

or a pharmaceutically acceptable salt thereof, for the manufacture of a medicament for the treatment of disorders where a calcium channel antagonist is indicated.

2. Use of a compound according to claim 1 wherein the disorder is a condition or disease related to an accumulation of calcium in the brain cells of a mammal.

3. Use according to claim 1 or claim 2 wherein the disorder is anoxia, ischaemia, migraine, epilepsy, traumatic head injury, drug addiction withdrawal or AIDS-related dementia.

4. Use of a compound according to any of claims 1 to 3 wherein p and r are independently 2 or 3.

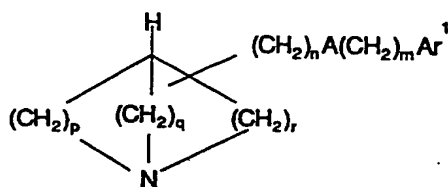
5. Use of a compound according to any of claims 1 to 4 wherein q is 1 or 2.

6. Use of a compound according to any of claims 1 to 5 wherein A is oxygen, -CH=CH- or a bond.

7. Use of a compound according to any of claims 1 to 6 wherein the length of the chain  $-(CH_2)_nA(CH_2)_m$  is from 2 to 6 atoms.

8. Use of a compound according to any of claims 1 to 7 wherein m is 0 to 3.

9. A compound of formula (IA) :



Formula (IA)

15 in which

p, q and r each independently represent an integer from 1 to 4;

n is 0 to 6;

m is 0 to 6; and

20 either

A is  $-C\equiv C-$  or  $NR^1$ , where  $R^1$  is hydrogen,  $C_{1-8}$ alkyl or phenyl $C_{1-4}$ alkyl; in which case  $Ar^1$  represents the group Ar as hereinbefore defined;

or A is a bond, in which case  $Ar^1$  represents the group Ar as hereinbefore defined with the proviso that when each of p, q and r is 2 and Ar is phenyl substituted by one or two groups selected from halogen,  $C_{1-4}$ alkoxy, nitro, cyano or amino, then the group  $-(CH_2)_nA(CH_2)_m$  is not  $C_{1-4}$ alkyl  $\alpha$  to the quinuclidine nitrogen atom or  $C_{2-4}$ alkyl  $\beta$  to the quinuclidine nitrogen atom,

30 or A is  $-CH=CH-$  in which case  $Ar^1$  represents the group Ar as hereinbefore defined with the proviso that when each of p, q and r is 2; n and m are both zero and Ar is mono- or di-chlorophenyl, the group  $-(CH_2)_nA(CH_2)_m$  is not  $\beta$  to the quinuclidine nitrogen atom.

or A is oxygen or sulphur in which case Ar<sup>1</sup> represents a group Ar<sup>2</sup> which is phenyl substituted by a C<sub>1-2</sub>alkylenedioxy group or by 1 to 3 substituents selected from SC<sub>1-4</sub>alkyl, OCF<sub>3</sub>, CF<sub>3</sub>, optionally substituted phenoxy, optionally substituted phenylC<sub>1-4</sub>alkyl and optionally substituted phenylC<sub>1-4</sub>alkoxy; or Ar<sup>2</sup> is

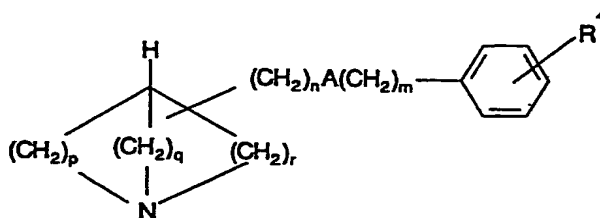
an optionally substituted bicyclic or tricyclic aryl group of up to 15 carbon atoms;

an optionally substituted benzofuranyl group; or

an optionally substituted tricyclic heteroaryl group;

or a salt thereof.

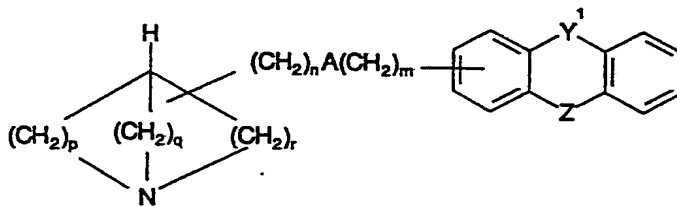
10. A compound of formula (IB) :



Formula (IB)

wherein p, q, r, n, m and A are as defined for formula (IA) and R<sup>4</sup> represents optionally substituted phenoxy, optionally substituted phenylC<sub>1-4</sub>alkyl or optionally substituted phenylC<sub>1-4</sub>alkoxy, or R<sup>4</sup> represents a fused benzene ring; or a salt thereof.

11. A compound of formula (IC) :



Formula (IC)

wherein p, q, r, n, m and A are as defined for formula (IA) and Y<sup>1</sup> and Z are as hereinbefore defined for formula (I); or a salt thereof.

12. A compound according to any of claims 9 to 11 wherein m is 0 to 3.

13. A compound of formula (I) selected from :

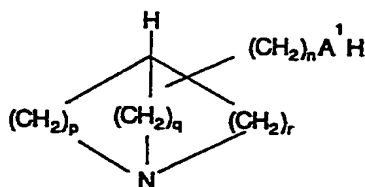
- (±)3-(3,4-dichlorophenoxymethyl)-1-azabicyclo[2.2.2]octane;
- (±)3-(4-benzyloxyphenoxymethyl)-1-azabicyclo[2.2.2]octane;
- 10 (±)3-(4-benzylphenoxymethyl)-1-azabicyclo[2.2.2]octane;
- (±)3-(2-phenylphenoxymethyl)-1-azabicyclo[2.2.2]octane;
- (±)3-(4-tert-butylphenoxymethyl)-1-azabicyclo[2.2.2]octane;
- (±)3-(1-naphthylloxymethyl)-1-azabicyclo[2.2.2]octane;
- (±)3-(2-dibenzofuranyloxymethyl)-1-azabicyclo[2.2.2]octane;
- 15 (±)3-(5-isoquinolinyloxy)methyl)-1-azabicyclo[2.2.2]octane;
- (±) endo-3-(4-benzylphenoxymethyl)-1-azabicyclo[2.2.1]heptane;
- (±) endo-3-(4-benzyloxyphenoxymethyl)-1-azabicyclo[2.2.1]heptane;
- (±) exo-3-(4-benzylphenoxymethyl)-1-azabicyclo[2.2.1]heptane;
- (±) exo-3-(4-benzyloxyphenoxymethyl)-1-azabicyclo[2.2.1]heptane;
- 20 (±) E-3-[2-(1-naphthyl)ethenyl]-1-azabicyclo[2.2.2]octane;
- (±)E-3-[2-(4-biphenyl)ethenyl]-1-azabicyclo[2.2.2]octane;
- (±)3-[2-(1-naphthyl)ethyl]-1-azabicyclo[2.2.2]octane;
- (±)3-[2-(4-biphenyl)ethyl]-1-azabicyclo[2.2.2]octane;
- (±)E-3-[3-(1-naphthyl)prop-2-enyl]-1-azabicyclo[2.2.2]octane;
- 25 (±)3-[3-(1-naphthyl)propyl]-1-azabicyclo[2.2.2]octane;
- (±)3-[2-(2-dibenzofuranyloxy)ethyl]-1-azabicyclo[2.2.2]octane;
- (±)3-[2-(4-benzyloxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane;
- (±)3-[2-(4-benzylphenoxy)ethyl]-1-azabicyclo[2.2.2]octane;
- (±)3-(4-phenoxyphenoxymethyl)-1-azabicyclo[2.2.2]octane;
- 30 (±) 3-[2-(4-phenoxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane,
- (±) 3-[4-(2-dibenzofuranyloxy)butyl]-1-azabicyclo[2.2.2]octane,
- (±) 3-[4-(4-phenoxyphenoxy)butyl]-1-azabicyclo[2.2.2]octane,
- (±) 3-[3-(4-phenoxyphenoxy)propyl]-1-azabicyclo[2.2.2]octane,
- (±) 3-[2-[4-(2-phenylethyl)phenoxy]ethyl]-1-azabicyclo [2.2.2]octane,
- 35 (±) 3-[2-[4-[2-(4-chlorophenyl)ethyl]phenoxy]ethyl]-1-azabicyclo[2.2.2]octane,

- (±) 3-[2-[5-(2-phenyl)benzo[b]furanyloxy]ethyl]-1-azabicyclo[2.2.2]octane,  
 (±) 2-[2-(4-benzylphenoxy)ethyl]-1-azabicyclo[2.2.2]octane,  
 (±) 2-[2-(4-benzoyloxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane,  
 (±) 2-[2-(4-phenoxyphenoxy)ethyl]-1-azabicyclo[2.2.2]octane, and  
 5 (±) 4-[2-(4-phenoxyphenoxy)ethyl]-1-azabicyclo[3.3.1]nonane,

or a salt thereof.

14. A process for the preparation of a novel compound of formula (I) which  
 10 comprises:

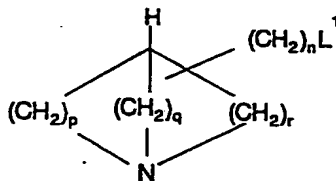
- (a) for compounds of formula (I) in which A is O, S or NR<sup>1</sup>, reaction of a compound  
 of formula (II):



Formula (II)

- in which p, q, r and n are as described for formula (I) and A<sup>1</sup> is O, S or NR<sup>1</sup>, with a  
 20 compound of formula L(CH<sub>2</sub>)<sub>m</sub>Ar in which m and Ar are as described for formula (I), and  
 L is a leaving group;

- (b) for compounds of formula (I) in which A is O, S or NR<sup>1</sup>, reaction of a compound  
 of formula (III):

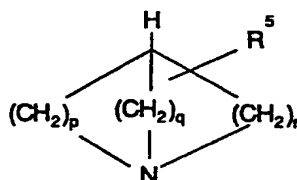


Formula (III)



in which p, q, r and n are as described for formula (I) and  $L^1$  is a group displaceable by a nucleophile, with a compound of formula  $HA^1(CH_2)_mAr$  where m and Ar are as described for formula (I) and  $A^1$  is as described for formula (II); or

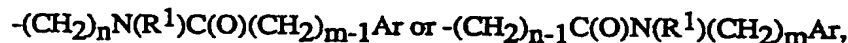
- 5 (c) for compounds of formula (I) in which A is  $NR^1$ , reduction of a compound of formula (IV) :



10

Formula (IV)

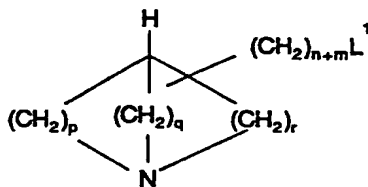
in which  $R^5$  represents the group



and p, q, r, n, m, and Ar are as described for formula (I);

- (d) for compounds of formula (I) in which A is a bond, reaction of a compound of formula (V) :

20

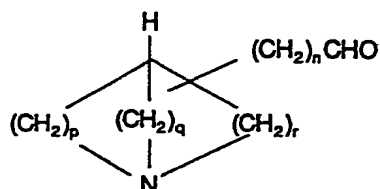


Formula (V)

- 25 (wherein  $L^1$ , p, q, r, m and n are as hereinbefore defined).

with a compound of formula  $X^1Ar$  in which Ar is as described for formula (I), and  $X^1$  is an alkali metal;

- 30 (e) For compounds wherein A is  $-CH=CH-$  reaction of a compound of formula (VI) :



Formula (VI)

- 5 (wherein n, p, q and r are as hereinbefore defined) with a Wittig reagent serving to introduce the group Ar;
- (f) Interconversion of one compound of formula (I) to a different compound of formula (I) e.g. the reduction of a compound wherein A is  $-\text{CH}=\text{CH}-$  to a compound
- 10 wherein A is  $-\text{CH}_2\text{CH}_2-$ ;
- and optionally thereafter forming a salt.
- 15 15. A pharmaceutical composition comprising a novel compound of formula (I) or a pharmaceutically acceptable salt thereof and a pharmaceutically acceptable carrier or excipient.
- 20 16. A method of treatment of a condition or disease related to the accumulation of calcium in the brain cells of a mammal which comprises administering to a subject in need thereof an effective amount of a compound of formula (I) or a pharmaceutically acceptable salt thereof.

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 93/00175

| <b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup><br>According to International Patent Classification (IPC) or to both National Classification and IPC<br>Int.Cl. 5 C07D453/02;      A61K31/395;      C07D487/08;      C07D471/08   |  |                                     |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
|---|--|-------------------------------------|---|--|--|---|---|---|---|--|---|---|---|---|---|--|---|---|---|---|
| <b>II. FIELDS SEARCHED</b><br><div style="text-align: center; margin-top: 10px;">Minimum Documentation Searched<sup>7</sup></div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; padding: 5px;">Classification System</td> <td style="padding: 5px;">Classification Symbols</td> </tr> <tr> <td style="padding: 5px;">Int.Cl. 5</td> <td style="padding: 5px;">C07D</td> </tr> </table> <div style="text-align: center; margin-top: 10px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched<sup>8</sup></div>  |  |                                     | Classification System   | Classification Symbols   | Int.Cl. 5  | C07D  |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| Classification System   | Classification Symbols   |                                     |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| Int.Cl. 5   | C07D   |                                     |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| <b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%; padding: 5px;">Category <sup>9</sup></th> <th style="width: 70%; padding: 5px;">Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup></th> <th style="width: 20%; padding: 5px;">Relevant to Claim No.<sup>13</sup></th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">           EP,A,0 412 797 (MERCK SHARP &amp; DOHME LTD.)<br/>           13 February 1991<br/>           * example 10, 19-21, 25, 37, 43, 47 *<br/>           ---         </td> <td style="text-align: center; vertical-align: top; padding: 5px;">9</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">           EP,A,0 327 155 (MERCK SHARP &amp; DOHME LTD.)<br/>           9 August 1989<br/>           * example 2, 4-6, 8, etc. *<br/>           ---         </td> <td style="text-align: center; vertical-align: top; padding: 5px;">9</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">           WO,A,9 114 686 (NOVO NORDISK A/S)<br/>           3 October 1991<br/>           * complete document *<br/>           ---         </td> <td style="text-align: center; vertical-align: top; padding: 5px;">9</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">           EP,A,0 416 754 (MERCK SHARP &amp; DOHME LTD.)<br/>           13 March 1991<br/>           * complete document *<br/>           ---         </td> <td style="text-align: center; vertical-align: top; padding: 5px;">9</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">X</td> <td style="padding: 5px;">           EP,A,0 327 155 (MERCK SHARP &amp; DOHME LTD.)<br/>           * complete document *<br/>           ---<br/> <div style="text-align: right;">-/--</div> </td> <td style="text-align: center; vertical-align: top; padding: 5px;">9</td> </tr> </tbody> </table> |  |                                     | Category <sup>9</sup>   | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>             | Relevant to Claim No. <sup>13</sup>  | X   | EP,A,0 412 797 (MERCK SHARP & DOHME LTD.)<br>13 February 1991<br>* example 10, 19-21, 25, 37, 43, 47 *<br>--- | 9 | X | EP,A,0 327 155 (MERCK SHARP & DOHME LTD.)<br>9 August 1989<br>* example 2, 4-6, 8, etc. *<br>--- | 9 | X | WO,A,9 114 686 (NOVO NORDISK A/S)<br>3 October 1991<br>* complete document *<br>--- | 9 | X | EP,A,0 416 754 (MERCK SHARP & DOHME LTD.)<br>13 March 1991<br>* complete document *<br>--- | 9 | X | EP,A,0 327 155 (MERCK SHARP & DOHME LTD.)<br>* complete document *<br>---<br><div style="text-align: right;">-/--</div> | 9 |
| Category <sup>9</sup>   | Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>             | Relevant to Claim No. <sup>13</sup> |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| X   | EP,A,0 412 797 (MERCK SHARP & DOHME LTD.)<br>13 February 1991<br>* example 10, 19-21, 25, 37, 43, 47 *<br>---              | 9                                   |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| X   | EP,A,0 327 155 (MERCK SHARP & DOHME LTD.)<br>9 August 1989<br>* example 2, 4-6, 8, etc. *<br>---                           | 9                                   |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| X   | WO,A,9 114 686 (NOVO NORDISK A/S)<br>3 October 1991<br>* complete document *<br>---  | 9                                   |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| X   | EP,A,0 416 754 (MERCK SHARP & DOHME LTD.)<br>13 March 1991<br>* complete document *<br>---                                 | 9                                   |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| X   | EP,A,0 327 155 (MERCK SHARP & DOHME LTD.)<br>* complete document *<br>---<br><div style="text-align: right;">-/--</div>    | 9                                   |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>10</sup> Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p> </div> </div>   |  |                                     |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
| <b>IV. CERTIFICATION</b> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">           Date of the Actual Completion of the International Search<br/> <div style="text-align: center; margin-top: 10px;">08 APRIL 1993</div> </td> <td style="width: 50%; padding: 5px;">           Date of Mailing of this International Search Report<br/> <div style="text-align: center; margin-top: 10px;">13. 05. 93</div> </td> </tr> <tr> <td style="padding: 5px;">           International Searching Authority<br/> <div style="text-align: center; margin-top: 10px;">EUR PEAN PATENT OFFICE</div> </td> <td style="padding: 5px;">           Signature of Authorized Officer<br/> <div style="text-align: center; margin-top: 10px;">VAN BIJLEN H.</div> </td> </tr> </table>  |  |                                     | Date of the Actual Completion of the International Search<br><div style="text-align: center; margin-top: 10px;">08 APRIL 1993</div> | Date of Mailing of this International Search Report<br><div style="text-align: center; margin-top: 10px;">13. 05. 93</div> | International Searching Authority<br><div style="text-align: center; margin-top: 10px;">EUR PEAN PATENT OFFICE</div> | Signature of Authorized Officer<br><div style="text-align: center; margin-top: 10px;">VAN BIJLEN H.</div> |   |   |   |  |   |   |   |   |   |  |   |   |   |   |
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| International Searching Authority<br><div style="text-align: center; margin-top: 10px;">EUR PEAN PATENT OFFICE</div>  | Signature of Authorized Officer<br><div style="text-align: center; margin-top: 10px;">VAN BIJLEN H.</div>                  |                                     |   |  |  |   |   |   |   |  |   |   |   |   |   |  |   |   |   |   |

| III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET) |   |                       |
|--|---|-----------------------|
| Category *   | Citation of Document, with indication, where appropriate, of the relevant passages  | Relevant to Claim No. |
| A  | CHEMICAL ABSTRACTS, vol. 115,<br>1991, Columbus, Ohio, US;<br>abstract no. 149760y,<br>V.E. DEGTYAR ET AL. 'Common<br>characteristics of calcium-channel and<br>muscarinic-cholinergic receptor<br>inhibitors.'<br>page 18 ;<br>see abstract<br>& 'Dokl. Akad. Nauk SSSr 1991,318(1),<br>221-3' | 1                     |
| P,X  | EP,A,0 470 668 (MERCK SHARP & DOHME LTD.)<br>12 February 1992<br>* complete document *  | 9                     |
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**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9300175  
SA 69757

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| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) |         | Publication<br>date |
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| WO-A-9215579                              | 17-09-92            | AU-A-                      | 1752792 | 06-10-92            |

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